THE

PROCEEDINGS

OF THE

LINNEAN SOCIETY

OF

NEW SOUTH WALES

FOR THE YEAR

1926

VOL. LI.

WITH FORTY-EIGHT PLATES
and 227 Text-figures.

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CONTENTS OF PROCEEDINGS, 1926.

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(Issued 15th April, 1926.)

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PART IV. (No. 208).

(Issued 15th December, 1926.)

PART V. (No. 209.)

(Issued 23rd February, 1927.)

CORRIGENDA.

Page 1, lines 4-5.—Dr. Tillyard is incorrect in stating that the wing referred to in lines 1-10 was lost. Mr. J. Mitchell states that the wing whose discovery was announced by him in 1898 (These PROCEEDINGS, 1898, 437) was actually collected in January, 1894, and was described by Dr. Tillyard as *Permoscarta mitchelli* (These PROCEEDINGS, 1917, p. 728). The specimen which was lost was one collected by Mr. Mitchell from the Belmont quarries in 1898.

Page 511, line 8.—*Nyctozoilus macleayi*, n. sp., has already been used (These PROCEEDINGS, 1926, p. 68). The insect described on page 511 is now considered a synonym of *N. reticulatus* Bates, see page xliii.

LIST OF NEW TRIBAL, FAMILY AND GENERIC NAMES PROPOSED IN THIS VOLUME (1926).

LIST OF PLATES.

PROCEEDINGS, 1926.

PROCEEDINGS

OF THE

LINNEAN SOCIETY

OF

NEW SOUTH WALES

WEDNESDAY, 31ST MARCH, 1926.

The Fifty-first Annual General Meeting, together with the Ordinary Monthly Meeting, was held at Macleay House, 16 College Street, Sydney, on Wednesday evening, 31st March, 1926.

ANNUAL GENERAL MEETING.

Mr. H. J. Carter, B.A., F.E.S., President, in the Chair.

The Minutes of the preceding Annual General Meeting (25th March, 1925) were read and confirmed.

PRESIDENTIAL ADDRESS.

The celebration of the Society's Jubilee took place during the past session. The Jubilee dinner, held on 2nd April last, and attended by fifty members and friends, was a successful and enjoyable function at which the Society was honoured by the presence of Mr. T. R. Bavin, who proposed the health of the Society, Dr. C. Anderson, President of the Royal Society of New South Wales, and Mr. G. A. Julius, President of the Institution of Engineers, Australia. A special publication, containing a brief history of the Society's first fifty years, was issued to members and to societies and institutions on the exchange list, whilst, as an additional reminder of Sir William Macleay's beneficence, copies of the Macleay Memorial Volume, published in 1893, were offered to fifty societies and institutions in various parts of the world.

During the year a favourable opportunity presented itself of disposing of the remaining portion of the Society's land at Elizabeth Bay and the Council completed the disposal of the property. Part of the agreement made gives the Society a lease of the Hall for one year free of rent and for a further period of two years at a rental agreed on with the purchaser. The Council is now considering ways and means with a view of providing accommodation for the whole of its activities

at Macleay House. This will mean the provision of a place for the library, which will then be easy of access to members.

The property at 16 College Street has been brought under the *Real Property Act* and the Society now has been granted title to a small portion at the rear to which previously its only title was by possession.

Some years ago the publications of scientific and technical societies were refused transmission through the post at the rates applicable to books or magazines, and many attempts were made, but without success, to have these publications classified as books by the Postmaster-General's Department. This action of the Department involved a heavy expense to societies whose main object was the dissemination of the results of research. During the past year, we are happy to say, representations made at the instance of the Council of the Institution of Engineers, Australia, have been successful and the publications of Australian scientific and technical societies are now accepted at the rate of postage applicable to magazines.

The efforts of the Australian National Research Council to bring into existence a Chair of Anthropology in Australia have been crowned with success. The Chair has been established in the University of Sydney and, on the recommendation of a committee of selection consisting of Professor J. T. Wilson, Professor Grafton Elliot Smith and Dr. A. C. Haddon, was offered to Professor A. Radcliffe-Brown, M.A., Professor of Social Anthropology in the University of Cape Town, who has signified his acceptance of the offer and will shortly arrive in Sydney. Professor Radcliffe-Brown has had a distinguished career in Anthropology and we may look forward to the development of a vigorous and successful department and the stimulation of a widespread interest in Australian anthropological problems.

The Great Barrier Reef Committee has devoted much attention to the problem of boring at selected points on the Reef in the hope that a study of the bore cores will contribute towards the elucidation of the many problems that exist in connection with the Reef and its origin. Arrangements have now been completed for bores to be put down during the coming winter. It is to be hoped that the energies of the Committee will not be confined to the boring and the physiographical studies already undertaken. There are many zoological problems closely associated with the Great Barrier Reef, and some of them have important possibilities from an economic point of view and the achievement or partial achievement of the solution of some of these problems would place the Committee in a strong position when it has to make any further appeal for assistance in carrying out its objects.

The concluding part of Volume L of the Society's Proceedings has been issued. The complete volume (561 plus lxxxvi pages, 50 plates and 242 text-figures) contains forty-one papers from thirty-four authors, the papers covering an unusually wide range of subjects in Natural History. The Society's research staff contributed eight papers.

Members will be pleased to know that the Council has approved the preparation of an index to the contributions to the first fifty volumes of Proceedings, and that the work of preparing the index is well advanced.

Exchange-relations with scientific societies and institutions have been well maintained, the receipts for the session numbering 1,409, as compared with 1,457 and 1,450 for the previous sessions. The following names have been added to the exchange list during the year: Botanical Institute, Prague, Bureau of Applied Botany, Leningrad, Finnish Zoological-botanical Society, Geological Survey of

China, Puget Sound Biological Station, University of Central Asia, Tashkent, and Welsh Plant Breeding Station.

The three vacancies in the Council caused during the year by the resignation of Mr. T. Steel and the deaths of Professor Haswell and Mr. McCulloch were filled by the election of Messrs. E. Cheel, G. M. Goldfinch and A. F. Basset Hull.

The Society has suffered a severe loss by the resignation of Mr. J. H. Campbell from the office of Honorary Treasurer in consequence of his appointment as Deputy Master of the Royal Mint at Ottawa. Mr. Campbell had been Hon. Treasurer of the Society for eighteen years, during which time he had commanded the fullest confidence of the Council in his handling of the financial affairs of the Society. On numerous occasions during his period of office the Society's finances have required very careful attention and the Society owes a great debt of gratitude to Mr. Campbell for the amount of work that he has done for the Society and for the very capable manner in which he has done it. It gives me great pleasure to express our appreciation of Mr. Campbell's work and to offer him our congratulations on his new appointment as well as our best wishes for a happy and successful period of office in Canada.

The Council has elected Dr. G. A. Waterhouse as Honorary Treasurer in place of Mr. Campbell. Dr. Waterhouse has been a member of the Finance Committee for some time and has, for many years, been in close touch with the Society's financial affairs. We may, therefore, rest assured of a continuation of the high standard set by past Treasurers in the management of the Society's finances.

I have much pleasure in offering the Society's heartiest congratulations to:

Mr. R. H. Cambage, C.B.E., on the honour conferred on him by His Majesty the King; Mr. Charles Hedley on the award to him of the Clarke Memorial Medal by the Royal Society of New South Wales; Professor A. N. Burkitt on his appointment to the Chair of Anatomy in the University of Sydney as successor to the late Professor J. I. Hunter; Sir T. W. Edgeworth David, on whom the University of Cambridge has conferred the degree of D.Sc.

Mr. R. H. Cambage has joined the ranks of those who have retired from official duties and we take this opportunity of wishing him very many years of health and happiness and enjoyment of the "busy" leisure which we know will be his lot.

During the past year the names of thirteen members have been added to the roll, and five names have been removed from it, one member has resigned and we have lost five members by death. The number of ordinary members on the roll is now 167. Death has taken heavier toll than for many years, the losses including Messrs. J. H. Maiden, T. Steel, A. R. McCulloch, three members of the Council, as well as Messrs. O. B. Lower and W. L. May.

Oswald Bertram Lower, who died at Wayville, South Australia on 18th March, 1925, in his 62nd year, was born in Adelaide. He was known in the scientific world for his contributions to the study of the Australian Lepidoptera comprised in his numerous papers. A pharmaceutical chemist by profession, his interest in the Lepidoptera was one of his hobbies and in the course of his studies he amassed a fine collection of Australian moths and butterflies. He was also interested in philately, having one of the finest collections of stamps in Australia, and was a member of various philatelic societies. He was a prominent Freemason, being a Past Master of Barrier Lodge No. 173. He was well known on the concert platform in Broken Hill as the possessor of a notable baritone voice and was a life member of the Broken Hill Quartet Club. Mr. Lower had been a

member of our Society since 1891 and contributed eight papers to the Proceedings, all of which contained descriptions of new Australian Lepidoptera.

JOSEPH HENRY MAIDEN, who died on Monday, 16th November, 1925, was born at St. John's Wood, London, in 1859. He was educated at the City of London Middle Class School and the University of London. He was awarded a scholarship by the Fishmongers' Company of London tenable at Christ's College, Cambridge, but preferred to remain in London with the object of taking his science degree at the University of London. On account of his health he was ordered to take a sea voyage and in 1880 came to Australia. He did not intend to stay, but he found himself so benefited by the change of climate and in addition he was so favourably impressed by this land and its flora that he decided to remain, though this meant giving up the completion of his science course at London. The first Board of Technical Education in Sydney was formed about this time and it was proposed to establish a Technological Museum with material left from the Sydney International Exhibition of 1879-1880. In 1881, Mr. Maiden was offered, and accepted, the position of Curator of the Technological Museum, which he held until 1896. The Museum was housed in the Exhibition Building, which was completely destroyed by fire on 22nd September, 1882. A fresh start was made by the Curator in a galvanized-iron building in the Outer Domain behind the Sydney Hospital and during the following ten years great progress was made in building up the collections of the Museum; in 1893 the Museum was moved to its present home in Ultimo. In 1894 to his duties as Curator of the Museum, were added those of Superintendent of Technical Education. In 1896 Mr. Maiden was transferred to the Botanic Gardens, where he succeeded Charles Moore as Director and Government Botanist. This post he held until his retirement in 1924, after nearly 43 years of continuous service with the Government of New South Wales.

As a botanist Mr. Maiden built up for himself a reputation which places him amongst the leading pioneering botanists who have worked on the Australian flora. During his early years in Australia he took the keenest interest in Australian plants, especially those known to be of economic value or injurious to man and domestic animals, and one result of this was the publication of his work on "The Useful Native Plants of Australia (including Tasmania)" in 1889. About this time also he was in active correspondence with Baron von Mueller, Rev. W. Woolls and other botanists, this correspondence being responsible for the publication of very many useful and interesting observations on Australian plants. What may perhaps be regarded as his greatest contribution is his "Critical Revision of the Genus *Eucalyptus*", commenced in 1903 and still in progress when he died. The genus *Eucalyptus*, of so much importance in Australia, received the most exhaustive treatment in this work, of which 64 parts had already been issued, others being in the press, and the material for still others in course of preparation at the time of his death. Fortunately for Australian Botany, Mr. Maiden had almost completed the "Revision", having directed most of his energies towards this end during his last few years, and it is gratifying to know that it is to be completed. When the descriptions of the seeds and seedlings, which are to be figured in colour, are issued and the key to the species is published, the complete work will be a lasting monument to the ability and enthusiasm of this great botanist. Another valuable work, which was completed in 1924 at the 77th part, was the "Forest Flora of New South Wales", commenced in 1904. Apart from these two outstanding works, which in themselves would be notable for a single man's botanical achievement, Mr. Maiden

made innumerable contributions to botanical science in the form of papers contributed to scientific societies and notes to such journals as the *Agricultural Gazette of New South Wales* and the *Australian Forestry Journal.* When it is realised that in addition to the 64 parts of the "Revision" and 77 parts of the "Forest Flora", he contributed either alone or jointly with colleagues, 45 papers to the Journal of the Royal Society of New South Wales and 87 to our own Proceedings (during the years 1887-1920) one may indeed wonder whether any other has contributed so much to our knowledge of Australian plants or animals. Among his works, other than those mentioned above, reference may be made to the following series in our Proceedings: A series of ten papers, mostly notes and descriptions of new plants, in conjunction with Mr. R. T. Baker (1893-1895); nineteen papers with Mr. E. Betche (1896-1913), mostly under the title "Notes from the Botanic Gardens, Sydney", embracing descriptions of new Australian plants and interesting notes on rare plants and their distribution; nine papers with Mr. H. Deane (1896-1901), mostly containing observations on the Eucalypts of New South Wales. Mr. Maiden also made notable contributions in his papers on the floras of Lord Howe Island, Norfolk Island, and Pitcairn and Funafuti.

Mr. Maiden's services to Australian Science were not confined to his botanical contributions, for he was one of those who gave freely of his time and energy in an honorary capacity towards the management of various scientific societies with which he was connected. He was assistant honorary secretary of the Geographical Society of Australasia in 1883 and later Hon. Secretary; of the Royal Society of New South Wales he was President, 1896 and 1911, member of Council, 1891-1923, and Hon. Secretary 1893-1919; of the Australasian Association for the Advancement of Science he was Permanent Honorary Secretary, 1909-1922; and of our Society, President 1901-1903, and member of Council 1887-1922. He also took a great interest in the development of the Wattle League and of the Australian Forest League. In this record, as in his botanical work, few can compare with him in the extent of his service to Australian science.

The appreciation of his greatness is, to some extent, shown by the honours conferred on him by scientific societies in various parts of the world. He was elected Honorary or Corresponding Member of a number of Natural History, Agricultural and Pharmaceutical Societies in Europe and North America, and was honoured in a similar way by the Royal Societies of Queensland, South Australia, Tasmania and Western Australia.

He was elected a Fellow of the Royal Society of London in 1916; was awarded the Linnean Medal by the Linnean Society of London in 1915, the Mueller Medal by the Australasian Association for the Advancement of Science in 1922, and the Clarke Medal by the Royal Society of New South Wales in 1924; and was honoured by having the Imperial Service Order conferred upon him in 1916. He had been a member of this Society since 1883, and for very many years was a regular attendant at the meetings, taking a keen interest in the work of the Society. Though in his later years he was prevented by ill health from regular attendance he did not lose interest in the Society. He was always ready and willing to give others the benefit of his advice and experience and during his life in Australia he placed his knowledge and attainments at the service of his country; truly it may be said that "service" was his watchword.

William Lewis May was born at "Wamstead", near Bletchley, South Australia, in 1861, and went with his father to Tasmania in 1874. Both his parents were good at drawing and painting and took a keen interest in Natural

History, his father more particularly in birds and his mother in shells. From the time the family went to Tasmania W. L. May worked hard on their farm, but he was able to find time for many other interests, included in which were his scientific hobbies. He was known in the scientific world for his outstanding works on the shells of Tasmania, his many years of labour on which resulted in his "Check-list of the Mollusca of Tasmania" and "Illustrated Index of Tasmanian Shells" published in 1921 and 1923 respectively. His only contribution to our Proceedings was "A Revised Census of the Marine Mollusca of Tasmania" (in conjunction with Professor R. Tate) published in 1901. He was an active member of the Society of Friends in Hobart.

He died in Sydney on 1st September, 1925, on his return from a trip through the Pacific Islands, including Fiji, Samoa, etc., a trip to which he had looked forward for many years. He had been a member of this Society since 1902.

ALLAN RIVERSTONE MCCULLOCH, whose death took place at Honolulu on 30th August, 1925, was born in Sydney on 20th June, 1885. At an early age he developed a liking for natural history and also showed remarkable facility with a pencil. At the age of 13, in July, 1898, began an association with the Australian Museum, which lasted for the rest of his life. For the first three years he worked as a volunteer and for some years was assistant to Mr. Edgar Waite who later went to New Zealand and is now Director of the South Australian Museum. Mr. Waite gave him every help and encouragement until, in 1906, on the former's departure, McCulloch was appointed Assistant-in-Charge of the Vertebrate section. By this time he had made up his mind to devote himself to the study of fishes, and his numerous contributions to our knowledge of this group are largely responsible for the sound basis on which the study of Australian Ichthyology has been developed. Perhaps no greater tribute has been paid to McCulloch's work on fishes than the statement of Dr. David Starr Jordan that he was "unquestionably the greatest authority on fish in the southern hemisphere, and one of the eight men in the world who really knew about fish". Apart from his profound knowledge of fishes he was interested in other branches of Natural History and, in particular, was an authority on decapod Crustacea.

Although not of robust physique McCulloch never spared himself in his enthusiasm for his work. During his trips to the Great Barrier Reef he had donned diver's dress and descended into the dangerous waters of Torres Strait; at Lord Howe Island he had performed hazardous feats of cliff-climbing as if they were nothing out of the ordinary; and he accompanied Captain Frank Hurley on an adventurous expedition into Papua in 1922. The final result of his unrestrained enthusiasm for his work was a complete breakdown in health some two years before his death. During this last two years his health was most unsatisfactory and at the time of his death he was on extended leave, granted in the hope that a prolonged rest would result in a restoration to good health. But this was not to be and his lamented death leaves Natural History the poorer by one of its brilliant devotees. McCulloch was a likeable man and one who made friends; we may quote, from the *Pan-Pacific Union Bulletin*, the impression he made in a short time in a land of strangers whither he had gone to attend the Second Pan-Pacific Food Conservation Conference: "During his stay of six weeks in Hawaii, Mr. McCulloch made many friends. He possessed an unusually pleasing personality, and because of his background as an explorer and scientist, scholar and gentleman, musician, artist and lovable friend, was much sought after".

Most of the results of his scientific work were published in the official publications of the Australian Museum. He had been a member of this Society

since 1907 and was elected a member of Council in 1924. He appreciated his election as a Councillor very highly and was keenly disappointed when he considered it his duty to tender his resignation on account of the state of his health. As, however, the Council preferred to grant him leave of absence in the hope that his health would recover he did not have to sever his connection with the Council in this way.

He contributed three papers to the Proceedings during the years 1912-1921. Of his published work on Fishes mention may be made of the "Check List of the Fishes of New South Wales", issued by the Royal Zoological Society of New South Wales and "List of the Fishes recorded from Queensland Waters" (in conjunction with G. P. Whitley) in the *Memoirs of the Queensland Museum*.

THOMAS STEEL, who died on 17th August, 1925, was born at Milton, Glasgow, Scotland, on 8th September, 1858. He was educated at the Greenock Academy and the Collegiate School, Greenock and very early showed a decided taste for Natural History. At the age of fifteen he entered the laboratory of Messrs. Patterson and Ogilvie, public analysts, Greenock, as junior assistant and after several years there went as assistant chemist to the sugar refinery of Messrs. J. Walker and Co., Greenock. He was very soon promoted to the position of chemist which he occupied for nearly five years and then he spent two years at practical work in the refinery. In 1882 he accepted a position with the Colonial Sugar Refining Co. of Sydney, in whose service he remained until his retirement in 1918. During the early years of his service with the Colonial Sugar Refining Company he was engaged at their factories and refineries in New South Wales, New Zealand, Fiji and Melbourne, but from 1893 onwards was employed in Sydney. He did a good deal of work on the post-Tertiary clays of the Greenock district between 1875 and 1882 and gathered a fine collection of the shells, etc., found there; this collection was presented to the James Watt Museum in Greenock where it still remains as a monument of his industry. About 1880 he was one of the founders of the Greenock Natural History Society which is still active. In Australia he was always interested in the Natural History societies and especially in the Field Naturalists' Clubs where he took a delight in helping the younger people who showed an interest in the various branches of Natural History. He made numerous contributions to the "Victorian Naturalist" and to the journal of the Field Naturalists' Club (afterwards the Naturalists' Society) in Sydney and was Hon. Editor of the latter, "The Australian Naturalist", from October, 1911, until his death. His published papers, many of which were on chemical subjects, were distributed in a number of journals, amongst which may be mentioned the Journal of the Society of Chemical Industry, the Reports of the Australasian Association for the Advancement of Science and the Proceedings of our own Society, to which he contributed some twenty papers. His earlier contributions to our Proceedings were mainly descriptions of Australian Land Planarians and notes on *Peripatus*, while during the last few years of his life, after his retirement, he gathered together many notes that he had made at various times and published them as a series of short papers in the Proceedings between 1919 and 1924.

He had been a member of the Society since 1886, a member of Council since 1897, and was President for the two sessions 1905-06 and 1906-07. He was also President of the Field Naturalists' Club, Sydney, in 1903-4, and Chairman of the Sydney Section of the Society of Chemical Industry in 1910-11.

Two noted zoologists in whom the Society has had more than ordinary interest in days gone by, have died during the year: Professors A. Dendy and S. J. Johnston.

ARTHUR DENDY, late Professor of Zoology at King's College, University of London, was well known to Australian zoologists. He came to Australia in 1888 as assistant to Professor Baldwin Spencer, and in 1894 was appointed Professor of Biology at Canterbury College, New Zealand. In 1903 he went to the University of Cape Town as Professor of Zoology, but two years later returned to London where he occupied the Chair of Zoology at King's College from 1905 till his death. He revisited Australia with the British Association in 1914 when he renewed acquaintance with many friends. He was a member of this Society from 1893 to 1899 and contributed three papers to the Proceedings, two dealing with *Peripatus* and the third with some land Planarians from the Blue Mountains.

STEPHEN JASON JOHNSTON, who died on 16th July, 1925, was formerly Professor of Zoology at the University of Sydney, where he succeeded the late Professor Haswell in 1918. He had been a member of the staff of the Zoology Department since 1906 and was a stimulating lecturer and demonstrator to the practical classes for many years. He graduated in Arts at Sydney in 1894 and in Science in 1902, gaining his doctorate in scienee in 1912 for his thesis on the Trematodes of Australian Frogs. A little less than three years after appointment to the Chair of Zoology his health gave way and he was forced to take a long holiday. As his health did not improve he resigned at the beginning of 1922, and did not long survive his former chief who had died only a few months before him. Professor Johnston was a member of this Society from 1899 to 1921 and contributed six papers to the Proceedings.

The year's work of the Society's research staff may be summarized thus:

Dr. R. Greig-Smith, Macleay Bacteriologist of the Society, has been investigating the activity of the mineral colloids such as silica, fuller's earth, talc and also other substances, such as charcoal and ferric hydrate, upon fermentation. The fermentation of dextrose and the rate of inversion of saccharose by yeast was hastened in the presence of these substances. Yeast was therefore affected by colloids in a manner similar to bacteria and comes under a common rule.

The inversion of sugar by the invertase-secreting *Bac. levaniformans* was hastened by the mineral colloids and by charcoal while the inversion of saccharose by invertase obtained from yeast was unaffected.

Similarly the ammoniacal fermentation of urea was accelerated by the colloids which had no influence upon the activity of the enzyme urease. Again, the colloids had a slight effect upon the diastatic fermentation of starch by *Bac. levaniformans* and none upon the action of malt diastase.

The investigation has shown that these mineral colloids accelerate yeast and bacterial fermentations, but do not assist the enzymic change; they hasten the growth and activity of living cells but have no action upon the isolated ferments.

Work is in progress to elucidate the reasons for the activity of the colloids. It is possible that they may accelerate alcoholic fermentation by assisting the diffusion of the carbon dioxide from the fermenting fluid. This matter has been under investigation and will shortly be reported upon.

Miss May M. Williams, Linnean Macleay Fellow of the Society in Botany, has continued her investigations by following out the processes of oogenesis and spermatogenesis in *Vaucheria geminata* with the object of ascertaining whether nuclear divisions, either homotypic or heterotypic, take place in the development of the sexual organs. The results so far obtained indicate an entire absence of such nuclear divisions, thus offering serious difficulties for various authors who consider that there is an essential agreement between the processes of oogenesis

in *Vaucheria* and various fungi, such as the Saprolegniales and Peronosporales, where such divisions do occur. The results of this investigation will be embodied in a paper to be submitted to the Society at an early date. During the year Miss Williams published two papers in the Proceedings, "Contributions to the Cytology and Phylogeny of the Siphonaceous Algae. i. The Cytology of the Gametangia of *Codium tomentosum*", and "The Anatomy of *Lindsaya linearis* and *Lindsaya microphylla*". She proposes to continue her work by examining the development of the gametangia in *Bryopsis*, and also to make further search for the reproductive organs of *Caulerpa* which are so far unknown.

Mr. P. D. F. Murray, Linnean Macleay Fellow of the Society in Zoology, has devoted the greater part of his attention during the past year to a series of experiments on the limbs of the embryonic chick. These experiments have provided the material for one of the most complete works on "self-differentiation" yet accomplished, and the results will be presented to the Society in the near future. They have provided evidence in favour of the Mosaic theory of limb-bud differentiation and also the means of studying the problems of a fundamental character involved in the first "determination" of limb tissues. During periods of enforced inactivity in the limb-bud work Mr. Murray commenced several short pieces of work on subjects which had come under his notice. One of them was carried to completion, the result being published in Part 4 of the Proceedings for 1925, as "A note on an unusual type of secreting epithelium in the Wolffian duct of the dog-fish (*Scylliorhinus canicula*)".

Mr. Murray, during the coming year, proposes to return to the work which he left to take up the limb-bud work, viz., an investigation into the reactions of the chorio-allantois of the chick to interference by grafting and other methods. Should this be completed before the end of the year he expects to commence a comparative study of the development of the two frogs, *Pseudophryne australis* and *P. bibronii* with special reference to the influence of different quantities of yolk on the development.

Dr. I. M. Mackerras, Linnean Macleay Fellow of the Society in Zoology, has published two papers in the Proceedings during the past year—"The Haematozoa of Australian Marine Teleostei", and "The Nemestrinidae of the Australasian Region". The latter comprises an extensive monographic review of the Nemestrinidae and is an extremely valuable addition to our knowledge of the Australian Diptera. In addition he has extended his studies of Australian Culicidae and of the male genitalia of the genus *Pelecorhynchus* and hopes at an early date to complete two further papers containing the results of these two pieces of work. During the coming year Dr. Mackerras proposes to complete his study of the Culicidae and to deal with other families of Diptera Brachycera along similar lines to his work on the Nemestrinidae with the object of providing adequate and reliable data for the study of problems of distribution. His work on blood parasites and Opalinidae will be continued as opportunity offers but will be subordinate to the studies on the Diptera.

Mr. G. D. Osborne, Linnean Macleay Fellow of the Society in Geology, commenced his year's work by completing for publication his paper on the petrography of the Carboniferous rocks of the Clarencetown-Paterson district. He then made a series of field trips in order to make a geological reconnaissance of the belt of Carboniferous rocks between The Pass, near Gresford and Aberdeen. These trips showed that detailed field work would be necessary for a correct interpretation of the structural geology of the country. Detailed field work was then carried out in the Glendonbrook and Mt. Mirannie districts, an area which

proved to have been extensively faulted, and later in the Sedgefield-Westbrook-Dyrring district; some attention was also paid to the country between Glendonbrook and the Paterson River. These field observations promise results of considerable interest, particularly with regard to some of the major faults of the area, and we may look forward to the completion of the two papers dealing with the subject which Mr. Osborne has in hand. Before the completion of Mr. Osborne's year as a Fellow the Senate of the University decided to re-establish the position of Lecturer and Demonstrator in Geology which had been dispensed with a year or so earlier and the position was offered to Mr. Osborne who signified his desire to accept. The Council thereupon agreed to accept his resignation as from 31st December, 1925, and I take this opportunity of wishing him every success in his work at the University and I may express the hope that his official duties will not prevent him from continuing his research work on the exceedingly interesting subject he has so well begun.

Dr. Walkom completed his examination of collections of Tasmanian Mesozoic Plants, a second paper being published in the Papers and Proceedings of the Royal Society of Tasmania for 1926. He also completed his study of a series of fossil plants from the Narrabeen Stage of the Hawkesbury Series the results of which appeared in Part 3 of the Proceedings for 1925.

Five applications for Linnean Macleay Fellowships 1926-27 were received in response to the Council's invitation of 30th September, 1925. I have pleasure in reminding you that the Council re-appointed Miss May M. Williams, Mr. P. D. F. Murray, Mr. G. D. Osborne and Dr. I. M. Mackerras to Fellowships in Botany, Zoology, Geology and Zoology respectively for one year from 1st March, 1926. Mr. Osborne, however, received the offer of a University appointment in December and the Council accepted his resignation as from 31st December, 1925. In view of Mr. Osborne's early retirement the Council called for fresh applications for the Fellowship thus rendered vacant, but finally decided not to make any additional appointment for 1926-27. On behalf of the Society I have pleasure in wishing all three Fellows a successful year's research.

Entomology—Past and Present.

The choice of Entomology as a subject should need no apology in a Society whose founder and first President was one of an illustrious trio of entomologists, a Society which actually sprang, phoenix-like, from the ashes of an entomological society, and which—besides the Macleays—has nourished such a series of workers in Entomology as King, Olliff, Skuse, Meyrick, Blackburn, Froggatt, Lea, Sloane, the two Turners, Waterhouse, Ferguson and Tillyard; two of whom have been honoured with that high Imperial scientific accolade, the F.R.S., and whose combined work has laid a fine foundation of knowledge of Australian insects of many orders. I propose here to offer a contrast between the past and present of Entomology, to show (1) how very modern is any scientific conception of the subject, and (2) the wide differences in matter and manner in its treatment.

The Past.—Nearly 3,000 years back, the Greek poet Homer was evidently a keen natural observer, though not generally regarded as an entomologist. He notes the "glancing gad fly" attacking the herds; one kind of worm or weevil attacking the wood of Odysseus' bow, another the corpses of cats; "Locusts flee from fire". Flies are often mentioned—as also frequently and poetically from Anzac in 1915. Old men of Troy, no longer able to fight, are "excellent talkers" like "tettixes" (? Cicadas) "which in the thickets, sitting on a tree, send forth a thin clear voice". Bees are "nesting in a hollow rock" apparently not yet domesticated.

The popular fictions so familiar to the Australian naturalist were evidently rife among the Greeks who named the most innocuous of insects (so far as animal life is concerned) *Buprestis* (the bull-stinger), cf. the common term *horse-stinger* employed in the bush for dragon-flies.

Five hundred years later Aristotle (384-322 B.C.) in his "History of Animals" enunciates the first classification known to me of all animals into two groups, *viviparous* and *oviparous*; the first contained quadrupeds; the second birds, fishes and insects. A leap of another five hundred years brings us to the Roman Pliny, one of the Pompeian victims of Vesuvius, who wrote a famous Natural History, whose notes are quoted here from the translation by John Bostock, F.R.S. (1855), "Beetles, in one large kind" (apparently *Lucanus cervus* L.) "we find horns of a remarkable length, two-pronged at the extremities and forming pincers which the animal closes when it is its intention to bite. These beetles are suspended from the neck of infants by way of remedy against certain maladies".

"In Lemnos there is a certain measure fixed by law, which each individual is bound to fill with locusts which he has killed, and then bring it to the magistrate".

From another source comes another locust story: "The Acridophagi—a people of Aethiopia living near the deserts. In the springtime they made provision of a large kind of locust which they salted and kept for their standing food all the year; they lived to 40 years of age, then died, as is said, of a sort of winged worms generated in their bodies". (Oxford Encyc.)

"Flies which have been drowned in water, if they are covered with ashes will return to life".

"The horns of an Indian ant, suspended in the temple of Hercules at Erythrae, have been looked upon as quite miraculous for their size. This ant excavates gold from holes". "It has the colour of a cat and is in size as large as an Egyptian wolf. This gold . . . . is taken by the Indians during the heats of summer, while the ants are compelled by the excessive warmth to hide themselves in their holes. Still, however, on being aroused by catching the scent of the Indians, they sally forth and frequently tear them to pieces, though provided with the swiftest camels for the purpose of flight; so great is their fleetness combined with their ferocity and their passion for gold".

"Many insects, however, are engendered in a different manner; and some more especially from dew. This dew settles upon the radish leaf in the early days of spring, but when it has been thickened by the action of the sun, it becomes reduced to the size of a grain of millet. From this a small grub arises, which at the end of three days becomes transformed into a caterpillar. For several days it increases in size, but covered with a hard husk, moves only when touched and is covered with a web like that of a spider. In this state it is called a chrysalis, but after the husk is broken it flies forth in the shape of a butterfly".

"In the copper smelting furnaces of Cyprus in the very midst of the fire there is to be seen flying about a 4-footed animal with wings, the size of a large fly. This creature is called the 'pyrallis' or by some the 'pyrausta'. So long as it remains in the fire, it will live, but if it comes out and flies a little distance from it it will instantly die".

"The life of other insects is regulated by multiples of 7. Thrice 7 days is the duration of the life of the gnat and of the maggot, while those that are viviparous live four times 7 days".

From Pliny to Oliver Goldsmith is a natural leap, for I find in the introduction to the latter's "History of the Earth and Animated Nature" these words:

"The delight which I found in reading Pliny first inspired me with the idea of a work of this nature".

Goldsmith divides the insect world thus:

(1) Wingless—ex. louse, spider. "All these, the flea and the wood louse only excepted, are produced from an egg".

(2) Winged—but wings "cased up", e.g. grasshopper, dragon-fly, ear-wig.

(3) Moths and butterfly kinds.

(4) Winged insects which come from a worm instead of a caterpillar, e.g. gnats, beetles, bees and flies.

(5) Zoophytes, e.g. polypus, earthworm and sea-nettle.

It is curious to note that Goldsmith's book was published in 1774, thirty-nine years after Linnaeus's publication of "Systema Naturae", from which the modern naturalist takes his zero time. But then Linnean Societies had not sprung into existence, books were rare and costly and international communications difficult. Linnaeus first divided insects into *four* orders, and subsequently into *seven*. (1) Coleoptera, (2) Hemiptera, (3) Lepidoptera, (4) Neuroptera, (5) Hymenoptera, (6) Diptera and (7) Aptera, surprisingly near the modern classification except in the last group which included termites, silver-fish, spiders, scorpions, centipedes, crabs and prawns.

My last two historical excerpts are taken from a learned work of 1828, "The Oxford Encyclopaedia" (7 octavo volumes). Under Entomology one reads "There is not perhaps, any branch of natural history, the study of which has been so generally regarded with indifference and contempt. The insect hunter is not infrequently treated with ridicule and his pursuit branded as frivolous".

A century later sees little to subtract from this statement so far as the popular view goes, as witness the typical entomologist of the stage and literature or the narrow escape from arrest of my friend Commander J. J. Walker, R.N., whom some of our members will remember as an interested and interesting guest of the Society eighteen years ago. This gentleman, later a member of the Council of the Entomological Society of London, of which he was President 1916-18, was pursued by the mounted police of Gosford and would have assuredly been locked up as a person of unsound mind had he not been able to refer to the local doctor as a friend who could certify that insect hunting did not necessarily imply a state of mind that was dangerous to the community. My second quotation from the Oxford Encyclopaedia shows the condition of economic entomology in Great Britain in the year that Australian settlement began.

"In 1788 an alarm was excited by the probability of importing in North American wheat that dreadful plague the Hessian fly. The Privy Council sat day after day to deliberate about prudential precautions, dispatches were written to the ambassadors in France, Austria, Prussia and America; Sir Joseph Banks held a voluminous correspondence across the Atlantic on the subject; the minutes of Council occupy more than 200 octavo pages; and after all, no satisfactory conclusion was obtained on the subject". Turning to the article "*Hessian fly*" in the same Encyclopaedia one reads that it was "a mischievous insect whose depredations threatened to destroy the wheat crops in N. America and that first appeared in Long Island during the American war and was supposed to have been brought from Germany by the Hessians but" (note the conclusion) "we believe its exact genus and species have not been discovered". (The well-known but still destructive *Mayetiola destructor*.)

The above historical notes show:

(1) The close interweaving of observation with pure fable that is characteristic of natural history literature of the earlier days of man—as it is of the more illiterate folk of to-day and of primitive man generally—(cf. the Australian aboriginal's knowledge of nature in combination with his firm belief in the "bunyip").

(2) The great dependence on "*authority*" and on superficial evidence that disappeared from scientific literature only with the slow growth of knowledge based on experiment and induction during the last century. Thus "Aristotle was *the* authority for 1,200 years on natural history as on ethical subjects, and the great theologians, like Aquinas, were convinced that it had pleased God to permit Aristotle to say the last word upon each and every branch of knowledge". (Robinson's "History of Western Europe".)

Compare this with Huxley's paraphrase of Hobbes's aphorism: "Books are the money of Literature, but only the Counters of Science".

(3) The time and paper used by the Georgian ministers in the Hessian fly trouble was not wasted and probably suggested the first harnessing of economic entomology to the Government coach.

The Present.—The great importance of the study of Entomology and its increasing penetration into practical politics can be shown in its relation to four wide branches of which there is only time here to sketch a few notes. These branches are:

(1) The Fundamental Lessons of Zoology—genetics, classification, evolution (including palaeontology); (2) Geographical Distribution and Ecology; (3) Economics; (4) Medicine.

(1) The Fundamental Lessons of Zoology.—The immense number of insects (in 1895 Sharp's Insect Census was 250,000; in 1925 Imms gives 450,000 spp.), their complexity of form and development, their close inter-relation and their vast geologic age give them a peculiar value to the student of evolution.

The best witness to this fact is A. R. Wallace, who, as an octogenarian, speaking at that memorable gathering of the Linnean Society in 1908 to celebrate the fiftieth anniversary of the joint communication made by Darwin and Wallace of their independent discoveries of natural selection, thus began his summing up of the reasons which in his opinion led Darwin and himself to the same theory.

"First (and most important as I believe) in early life Darwin and myself became ardent beetle-hunters. Now there is certainly no group of organisms that so impresses the collector by the almost infinite number of its specific forms, the endless modifications of structure, shape, colour and surface markings that distinguish them from each other, and their innumerable adaptations to diverse environments. Again both Darwin and myself had what he terms 'the mere passion for collecting'. I should describe it rather as an intense interest in the variety of living things—the variety that catches the eye of the observer even among those that are very much alike, but which are soon found to differ in several distinct characters.

"Now it is this superficial and almost child-like interest in the outward form of living things which, though often despised as unscientific, happened to be the *only one* which would lead us towards a solution of the problem of species. . . . It is the constant search for and detection of these often unexpected differences between very similar creatures that gives such an intellectual charm and fascination to the mere collection of these insects; and when as in the case of Darwin and myself, the collectors were of a speculative turn of mind, they were

constantly led to think upon the 'why' and the 'how' of all this wonderful variety in nature".*

He then gives two other reasons, as less important, (*a*) their becoming travellers, collectors and observers in some of the richest and most interesting lands, (*b*) both reading and being intensely struck by the system of checks as expounded by Malthus in his "Principles of Population". This evidence finds further corroboration in the "Origin of Species" by the large number of points in Darwin's argument taken from his study of British Coleoptera.

The prolific Australian insect fauna gives eminent examples of wide variation of species in its dominant genera. Thus, in the Coleoptera, *Stigmodera* with 300 species, or the polymorphic *Heteromera*, like *Adelium* and *Chalcopterus*, are three that occur to me out of the very large number of cases where the naturalist can see species in the making.

Australia with its huge area of lightly differentiated regions—at least so far as defined zoogeographic barriers are concerned, since its more populous faunal areas gradually merge into its suberemian regions—affords a fine field for the study of variation. The two special instances stated by Darwin are here well demonstrated. We possess large genera that range north, south, east and west of our island continent, but are non-existent or rarely found elsewhere. Of the groups with which I am familiar, *Adelium* and *Chalcopterus* of the Tenebrionidae, *Stigmodera* of the Buprestidae, and the Amycterid weevils are instances where this continental distribution is associated with wide variation; certain species are also very numerous in individuals and vary greatly *inter se.* The other case of small genera, but containing species of wide diffusion, shows in the Australian Coleoptera extraordinarily variable characters.

I have lately been trying to systematize a genus of ground, wingless longicorns, *Microtragus*. In 1917 Lea tabulated this genus and expressed the opinion that of one species, *M. senex* White, three of Blackburn's species were mere varieties while Pascoe had redescribed his own species *arachne* as *sticticus*. Having under view a large amount of material from the various Australian collections I am inclined to go further than Mr. Lea and lump the first four together with *three* (not two) of Pascoe's species (*arachne*, *sticticus* and *eremita*) under *senex* White "in one red burial blent". The species occurs from Eastern Queensland, through the Northern Territory to Western Australia and thence to South Australia and probably to inland parts of Victoria and New South Wales.

Until recently little was known of the effect of cross-breeding. Here Dr. Waterhouse's experiments in cross-breeding certain geographical races of the butterflies of the genus *Tisiphone* are of great value in supplying evidence in the place of speculation and conjecture. He is to be congratulated on his originality and industrious coordination of details in a branch of entomology that has immense possibilities.

In some groups of beetles that occur sparsely in or on the fringe of our great interior, e.g. the subfamilies Nyctozoilinae and Briseinae, we find small genera containing few species and showing primitive relations that indicate a disappearing race, a fact that seems to accord with Spencer's evidence of the gradual desiccation that is occurring over a large area of Australia. Opponents of Evolution frequently ask a question to which it has not been easy to find an answer. It is this: "Can you point to any definite species of animal life known to have originated within recent times"? To this question modern entomology, speaking

* Alfred Russell Wallace, Letters and Reminiscences (J. Marchant), 1916, p. 114-115.

through the mouth of Dr. C. B. Davenport, Director of the Department of Genetics, Carnegie Institution of Washington, replies: "There are now thousands of forms of animals and plants that reproduce their kind which did not exist a century ago. Within the last ten years there have been produced *scores of forms of the banana fly* never before seen by the eye of man. Indeed the very day on which the ancestors of some new types first appeared is known, and many of these types have persisted to the present day. We know indeed not a few forms which have appeared recently, and which fulfil the essential conditions of *species* as the naturalist finds them in nature. These forms differ by two or more constant traits from other species. They are quite as infertile with other species as some wild species are with each other. The principal difference between them and wild species is that their beginnings have been seen and are known to be recent, while that of wild species has not been seen, and so their origin is of unknown date". Australia has been quoted as a "land of living fossils", in possessing living forms elsewhere extinct. This is notably true of many orders of "Insects". Thus my friend, Mr. J. Clark, in his paper on "The Ants of Victoria", writes: "The Ponerinae are the most ancient group of ants, and are the stock from which the higher, specialised subfamilies arose. Nowhere are they a dominant group, except in Australia where according to Prof. W. M. Wheeler "these ancient insects occupy a position amongst ants analogous to that of the monotremes and marsupials among animals, and the Rhyncocephalia among reptiles. And it is especially the genus Myrmecia, comprising the 'Bull-dog' ants which may be said to characterize this fauna and at the same time to represent the prototype of all ants".

Many genera of Australian insects are as interesting to the student of genetics as its mammals, and almost as bizarre in the development of unusual characters, e.g. the basket-like palpi of *Tillyardia*, to which I can find no parallel in the Prionid longicorns of other countries, or the extraordinary development of the Australian *Helaeinae* (peculiar to Australia and New Guinea), of which more than 200 species occur. The nearest exotic ally is *Cossyphus* which, however, is placed in another subfamily and of which the species are so small and comparatively few (37 in Europe, Asia and Africa).

A valuable link in insect genetics was recorded by Mr. Gerald Hill* at the recent Pan-Pacific Science Congress in the close relation of certain female organs of the termites of the genus *Mastotermes* "in some respects the most primitive of all Isoptera" to the Blattidae (Cockroaches).

In this connection Dr. Bolton, the authority on British fossil insects, notes: "The frequent association of fossil insects with the Myriapoda and the Arachnidae in ironstones reminds him of the colonies of spiders, millipeds and cockroaches living under bark of trees in the bush of Australia".

Modern entomology has necessarily added palaeontology as another vast field of research. So modern is this that in 1908 only 13 fossil insects were known from the British Coal Measures; to-day 60 different species in five principal groups are known. Handlirsch in Germany, Brongniart in France, Scudder in America (followed by Cockerell and Wickham), Bolton in England and Tillyard in Australia have added extremely interesting and valuable evidence on the ancestry of the Insecta, the great work of the first, "Die fossilen Insekten", being the classic of the subject. There is no time here to say more than a few generalities on this world work. Thus the Cockroaches (the name is derived from the Spanish

* *Vide* also *Proc. Roy. Soc. Vict.* 1924, p. 120.

Cucarache) have an ancestry compared with which man is a mere modern upstart, and are so common in the Upper Carboniferous beds of England and Germany as to constitute 90% of its insect fauna, while 200 Palaeozoic species are known from Europe and America. These ancient roaches besides having two pairs of similar, often *neuropteroid* wings, sometimes, as in other families of Palaeozoic insects, possessed a pair of prothoracic wings or wing-like appendages. The cockroaches are found again in the Permian, but diminish in numbers compared with other insects in the Mesozoic fauna, a diminution continued to recent times.

Two notable facts emerge here, (1) that we have a more complete record of the evolution of these insects than of any other animal, although the well-known development of the horse has a more popular application, (2) that there is extraordinarily little difference between the cockroaches of Mesozoic times and those now living (miscalled in England Black-beetles) "so fit to survive that they have found no need of change". Here also are found gigantic dragon-flies "with a wing spread of two feet", while the ancestors of our mayflies were numerous and highly developed. According to Tillyard "the first known fossil Coleoptera are a few small elytra recently found at Belmont, New South Wales (Upper Permian) and assigned to the Hydrophilidae. In the Triassic beds of Ipswich the Coleoptera formed 47½% of the total insects".

Extraordinary, too, is Tillyard's evidence as to the close relation between the Mesozoic *Archepsychops* and a recent *Megapsychops* known from a mountain only 30 miles from the Ipswich fossil beds; the change throughout the immense period "being really only a change in the shape of the wing". Tillyard has also described two out of the three oldest known Homoptera, namely *Permoscarta mitchelli* and *Permofulgor belmontensis*, and by his further study of the Mesozoic beds of Ipswich has given a diagram showing the probable phylogeny of the Homoptera. The discovery of *Belmontia mitchelli* (Order Paramecoptera) by Mr. John Mitchell is another link in our genetic chain. Dr. Tillyard claims this to be definitely ancestral to the Trichoptera and Lepidoptera, of collateral descent with the Mecoptera and possibly ancestral to the Megaloptera and Planipennia. Further he notes that the dominant Insect Fauna of the Upper Permian (as shown at Newcastle and Belmont) "was a mixed one of Plant Hoppers (Homoptera) and Scorpion Flies (Mecoptera)", a fauna occurring to-day in the damp hollows of shady gullies or southern slopes of hillsides. In *Permochorista australica* (from the Newcastle Coal Measures) he claims to have found the first fossil Holometabolous Insect (having a complete metamorphosis)—the earliest known insects like Thysanura showing none, or incomplete metamorphosis.

Dr. Tillyard's qualification for this difficult branch of work is his mastership of the wing venation of insects, in which he stands to-day amongst the highest exponents of this as indeed of insect anatomy in general. Nevertheless, I should like to add my note of caution to that of a former President, Mr. Henry Deane, who protested against the determinations of fossil plants from mere leaf impressions and noted the consequent errors in plant distribution in Palaeozoic times. Insect fossils in general consist of small portions—"often only a tiny fragment—and these have been subjected to great pressure changes. When to this is added that in structure and relationship they" (often) "differ widely from living forms we cannot repress legitimate wonder that it has been possible to bring to life, from a few fragments of stone bearing obscure impressions so varied a swarm of unknown insects". (I am here quoting "Nature" on Dr. Bolton's fossils of the British Coal Measures.)

While these general determinations have their value, the species, genus and family must often be very obscure. Thus Dr. Tillyard tilts at Handlirsch and other authors as to the Order of the Jurassic family Palaeontinidae. If doctors differ as to the Order in which an insect should rank, the families must often be questioned, while Tillyard confesses to the use of "genera of convenience", and *species* must come under a still wider field of conjecture; always bearing in mind that one character alone—the wing venation often of a small area of wing—is generally the sole means of determination, or, in Coleoptera, the mere impression of an elytron.

In the "Origin of Species" (6th Edition, 1891, p. 115) I find this statement: "in the fossorial hymenoptera, the neuration of the wings is a character of the highest importance, because common to large groups; but in certain genera the neuration differs in the different species, and likewise in the two sexes of the same species". Again (*l.c.* p. 32): "It would never have been expected that the branching of the main nerves close to the great central ganglion of an insect would have been variable in the same species . . . . yet Sir J. Lubbock has shown a degree of variability in these main nerves in Coccus, which may almost be compared to the irregular branching of the stem of a tree". Also Dr. Waterhouse tells me that the wing venation sometimes differs in the two wings of the same individual insect in Lepidoptera. Is it not reasonable to expect considerable variation of this character in the early days of a race, when this—as other characters—were in flux or process of fixation?

In the summary of the Upper Triassic Fauna of Ipswich, Queensland, Tillyard records 122 species belonging to 63 genera, 32 families and 10 Orders, all found within a few square yards (74 described by Tillyard, the remainder by Dunstan). It is well known that floods often collect insects into condensed masses, in floating debris, grass, etc., and I have known of 200 species thus captured in one day. In the case of the Ipswich fossils these insects must not only have been swept together, but suddenly embedded in a suitable medium of mud, and finally their fragments incorporated in the rock. One cannot then repress (to use the phrase of Mr. Prevost in "Nature") "legitimate wonder" that it has been possible to determine 15 species of *Ademosyne* and 7 of an allied genus *Ademosynoides* in the sense that genera and species of existing insects are determined. Thus Tillyard describes two fossil Coleoptera (*Adelidium cordatum* and *Ulomites willcoxi*) as Tenebrionidae from elytral impressions, whereas I am sure no coleopterist would dare to distinguish a member of this family without evidence as to its tarsal formula, while the form and sculpture of elytra are often closely alike in many different families. Incidentally the former of the above two is not in the least like the recent genus *Adelium*. *Protocoleus* also seems to me to require further evidence of its affinity with the Order Coleoptera to allow of its assigned position.

On the subject of purely systematic work occasionally decried by the superior critics of science, I should like to give here the opinion of a great modern leader in entomology, Dr. L. O. Howard, from his address to the Entomological Society of America in 1924: "In spite of the hundreds of thousands of species of insects that have been named and described, a greatly larger number remain unnamed, while the stability of the names already adopted, and of many of the classificatory details and systems has by no means become fixed, and there is a sad lack of comprehensive catalogues of groups—a type of publication of the greatest use to all entomologists. There is, therefore, a crying need for many more capable taxonomists". "Further, there is also a crying need for bigger and broader

taxonomists—for the men entering the field to consider a host of things unconsidered in the old taxonomy" . . . . "internal anatomy, embryology, physiology and palaeo-entomology. We need a sounder and better based classification all through the group Insecta, and this is one of our prime needs to-day".

(2) *Geographical Distribution* must always be of extreme interest since insects in general are characteristic of their region. With the exception of a few cosmopolitan species—disastrously numerous in individuals—the great majority of Australian insects can be relegated to their respective faunal regions as delimited by Tate, Hedley and Sloane. Any Australian entomologist could rapidly determine of a typical collection of Australian insects the faunal region to which it belonged and very generally could say this of individual examples. Dr. Ferguson tells me that certain families of the Diptera are exceptions to this, having a wider distribution than other Orders. Specially interesting facts of zoogeography occur in species found along the mountain ranges from Victoria to the Mount Royal system in their Tasmanian affinities. Thus in the Coleoptera collected in January, 1925, by the Sydney University Expedition to Barrington Tops, the following facts are noteworthy. Of the ten species of Buprestidae taken, four are known specially as Tasmanian or Alpine Victorian; of the Tenebrionidae (remarkable as characteristic of a local fauna) 41% were purely local, while 33% were Southerners (Tasmanian or Victorian). Of the Cerambycidae (longicorns) all the winged forms, 75%, were species of wide distribution while the remaining 25%, the apterous *Athemistus* (four out of five species were new), whose allies occur chiefly along the ranges in New South Wales and Victoria, are apparently limited to the plateau. Mountain tops, especially plateau regions, provide endless problems in distribution, often as examples of faunal islands containing relics of past eras. A study of the insect fauna alone would indicate that Tasmania had been joined to the mainland, but that it had been separated long enough to allow of a considerable amount of independent development. The presence of *Phalidura* of the ground weevils and *Saragus* of the apterous Tenebrionidae are two amongst many instances that show this recent union. Similar evidence applies to the recent connection of New Guinea with Australia. Of 66 genera included in a recent study of the Papuan Tenebrionidae by Gebien* 34 (or 51%) are included in the Australian Fauna, while no less than sixteen species are found on both sides of Torres Strait (excluding cosmopolitan species).

Most significant, too, is the faunal relation of Australia with South America. In 1909 Dr. Waterhouse captured two examples of a dragon-fly in the Blue Mountains which was first diagnosed as *Phyllopetalia apollo* Selys from Chili, but later proved to be a distinct Australian species (*P. patricia* Till.) of a genus otherwise only recorded from Chili. I possess evidence of an opposite nature in which the beautiful genus *Curis* of the Buprestidae, containing some 14 recorded Australian species, includes also one, possibly two, Chilian species, of which Mons. Théry has courteously sent me an example of *C. bella* Guér., a species extraordinarily near some of our own.

Again the typical Australian genus *Stigmodera* has a close South American ally in *Conognatha* (the differences being slight and of only technical importance), the widely spread genus *Adelium* of Australia has a single representative in Chili, as also has the characteristic Australian genus *Cyphaleus* (*C. valdivianus* Phil. being closely related to our own species). Further research would doubtless

* Résultats de l'Expédition Scientifique Néerlandaise à la Nouvelle Guinée, 1920.

disclose other instances; but these are just as important links as are the floral relations of South Africa with Australia in its Proteaceae.

The almost total dissimilarity and wide divergences shown in a comparison of the New Zealand and Australian insects proclaims aloud their independent or widely disconnected origins. Except for certain cosmopolitan species spread by man's agencies, I know of only one beetle that is common to both faunas. This is a tiny, blind, sea-beach dweller (*Phycochus graniceps* Broun.), a scarab of the Aphodiinae group that has been found also at Hobart, Tasmania. Sand-beach insects are well known for their wide distribution; the genus *Trachyscelis* is found all over the world, *Caediomorpha heteromera* King is as common on Cottesloe Beach (W.A.) as at La Perouse (Botany). The entirely modern subject of Insect Ecology is now everywhere receiving attention, more especially in the United States. The effect of soil, light, temperature, moisture, food, biotic relations, symbiosis, parasitism, community life, physical environments, all contain matters for wide and deep research. With regard to soil alone—which in relation to plant life was so ably treated by our last President—I have found the somewhat rare Lucanid beetle *Rhyssonotus jugularis*, described from and associated with Mount Macedon and other volcanic regions of Victoria, at Mount Wilson. It will probably also be found on volcanic elevations elsewhere between these extremes. The small Tenebrionid *Platycilibè brevis* has so far only been found at Mount Wilson, Barrington Tops, Victorian volcanic mountains, and (*fide* Lea) Tasmania. It is not necessary to be a scientific entomologist to be aware of the connection between warmth and moisture and mosquito life, while every "bug hunter" knows the variations between good and bad seasons from his point of view—the bad being, in general, associated with dry conditions at the critical hatching periods. Again, the special adaptations of many of our insects to dry or eremian (to use Tate's phrase) conditions have been noted by Tillyard in an interesting paper read here in 1910 "On some experiments with dragon-fly laryae" when *Synthemis eustalacta* resisted drought and starvation for 154 days. Again in Perth, in reply to my question as to certain Phalidurid weevils, Mr. Henry Giles produced several live and active specimens of *Macramycterus* that had been kept in bare boxes in his room for some months without food or moisture. Other examples of this group were sent by mail to England arriving in good health. Tillyard's experiment with the larvae and pupae of the Cicada-hunting wasp (*Exeirus lateritius*) further shows the effect of moist or dry season—these missing a dry summer 1918-19 but hatching freely the following spring after good rains.*

A curious, and probably harmless, invasion has recently come under my notice. Dr. Ferguson caught an unusually brilliant Buprestid beetle at Port Macquarie (in the hotel back yard), which was quite unlike any indigenous genus. Later another specimen of the same species was sent me from Victoria to diagnose. In course of time I learnt from the British Museum that this was a well-known North American insect (*Buprestis aurulenta* L.), no doubt introduced in American timber in the larval or pupal stage. I strongly suspect one of W. S. Macleay's types in the Macleay Museum—labelled *Cisseis lapidosa*—of being a similar instance of an exotic taken alive in Australia. A remarkable habit in certain species of Coleoptera, *Macropocopris*, allied to the large world-wide genus *Onthophagus*, has lately (1920) been recorded by Mr. Gilbert Arrow, F.Z.S., F.E.S., of the British Museum. These insects were found in two instances by Dr. Illingworth

* These PROC. 1919, p. 720.

attached to the fur of wallabies in North Queensland, evidently awaiting the droppings which form the food of this group—in other instances they were found actually within the cloaca. That this was no exceptional occurrence is shown by the adaptive modifications of the feet. In *Onthophagus* the last joint and claws are very slender; the latter feeble and quite simple in form; but in *Macropocopris* this joint forms a strong grasping apparatus, and its enlargement makes the insects easily recognizable. A similar occurrence is the remarkable Staphylinid beetle *Cryptommatus jansoni* that the late Mr. Simson found at the base of the tail in Tasmanian rats, which has a close ally in the South American *Amblyopinus jelskyi* found similarly with certain indigenous mice. Again the genus *Clavigeropsis*, established by Raffray for a single Abyssinian Pselaphid having six-jointed antennae, found in ants' nests, has found a congener in *C. australiae* Lea found under similar conditions at Wollongong, New South Wales. The tiny beetles *Rodwaya* (Fam. Trichopterygidae), common in certain ants' nests in Australia, are very close to *Limulodes* species occurring in North and South America, while the minute genus of crickets, *Myrmecophila*, occurs with ants in every continent and on many islands.

Economic.—While the study of genetics, physiology and morphology of the subject appeals chiefly to the specialist, the economic aspect is now being grasped by the "man on the land", if not by the "man in the street", who demands immediate and palpable results from scientific work. This is no new phase of the popular view. Even Francis Bacon valued science only as it produced "fruits". What those who demand immediate fruits fail to understand is that most, if not all, of the great fruits of science have grown from the efforts of men who worked for the sheer joy of discovery. A former President, Mr. Froggatt, in 1912, gave an exhaustive review of the economic side of Entomology both in Australia and elsewhere to that date and I will try to avoid repeating the valuable information contained in his address. I wish rather to supplement his and Mr. Lucas's remarks as to the extreme importance of science as the handmaid of government, to refer to the great developments of modern methods, for thirteen years of science which include things learnt during 1914-18, are, to use the language of poetry, "worth a cycle of Cathay". But the experiences of recent years throughout the world greatly modify his general conclusion as to insect pests which, he says, when "carefully studied there is not one that cannot be checked and reduced until it becomes of no commercial importance".

Nowhere has economic entomology been carried farther than in the United States where the Federal Bureau of Entomology, under its famous enthusiast Dr. L. O. Howard, directs a staff of some 460 members, 386 of whom are engaged in scientific research, and specialists are continuously at work on field crops, tropical insects, stored grains, while an inner circle investigates those insects that affect the health of man and animals. "Our budget for the coming year" writes Dr. Howard "somewhat exceeds $2,500,000," "of which nearly one-half must be spent on the three specific problems of the gipsy moth, the European corn borer, and the Japanese beetle in *the effort to prevent their spread and to gain at least partial control.* Besides this Federal Bureau, each State has its own Department of Agriculture with experimental Stations, of which more than 70 are scattered over the country, besides those in Alaska, Hawaii, Porto Rico, Virgin Islands and Guam, altogether employing some two or three hundred more entomologists. Moreover, I read, in *Science Progress*, of a parasite laboratory of the U.S.A. Bureau at Hyères in the South of France, whence comes an important monograph by H. L. Parker on "Larvae of the Chalcidae".

Airplanes are now extensively used in the United States for distributing poison over the cotton plantations for the control of the boll weevil, as well as the leafworm "effectively and profitably as contrasted with the results of dusting with ordinary ground machinery". The military airplane has, however, been replaced by specially adapted 'planes and extensive plans are under way for more widespread use of this method. (Aeroplanes have also been used near Berlin to scatter arsenic preparations, and to pump down poison gas on plague caterpillars.)

By these and other great organizations some of the pests are being met with something like proportional offensive measures. Thus the great locust invasions are met by bodies of skilled men in a way analogous to the methods employed against great conflagrations by organized fire extinguishers. To show, however, how partial is this control of the greater pests, I will give a few facts from the "Annual Report" of the Federal Bureau for 1924 on the three great pests mentioned above.

(1) *The Gipsy Moth.*—In 1889 a scientist was conducting experiments in Massachusetts for improving the breed of silkworms, and attempted to develop a hardier moth whose larva would browse on scrub oak or sassafras by crossing the European gipsy moth with silkworm moths. A boisterous wind capsized his coop and the gipsy moths merged themselves in the landscape. Harmless in Europe, in America they multiplied prodigiously and devastated the trees in four States. Now for thirty years the fight has gone on with the outcome as yet uncertain. In 1924 the report states: "The scouting work was continued throughout the fall and winter. Gipsy moth colonies were found in 10 new towns in Vermont and 4 in Connecticut. The conservation department in New York located colonies in 9 towns east of the Hudson River. In the town of Alburgh (Vermont) within a mile of the Canadian border, a small wooded area was found that was heavily infested". "Heavy expenditure will be required during the coming year". "It cannot be done with inadequate funds". "Any course that promises less than adequate control will be expensive and unsatisfactory". As against this I note "Parasites and natural enemies of the gipsy moth were more abundant and effective this season in New England than ever before".

(2) *The European Corn Borer.*—"The most important developments of the past year have been the appearance of the pest on the western end of Long Island and the intensification of the infestation in the Ohio area". "The principal danger lies in the possibility of infested sweet corn moving to the New York markets and thence possibly to other parts of the U.S.". It then describes steps taken against this as well as "a large scale clean up campaign throughout the infested countries". Progress has been made in the work of importing parasites from its original home in Southern Europe. "Additional parasites are constantly being found and studied in the parasite laboratory at Hyères, France, before attempts are made to introduce them into the U.S.".

(3) *The Japanese Beetle.*—About a decade ago a New Jersey nurseryman imported some Iris roots from Japan, amongst which lurked a few stowaway beetles. In one season their progeny travelled 5 miles and then dug in for the winter. These beetles, while grubs, eat off the grass roots two inches below the ground so that the turf of a lawn may be rolled up like a blanket. In a single square yard of sod fifteen hundred of them have been counted. "Scouting to determine the limits of infestation it was found by the close of 1923 that the beetles had spread over a territory of some 2,500 square miles". "Owing to the increase in the infested area the farm products quarantine was changed from

one of inspection of products to the zone system". "It was necessary to establish an embargo by placing inspectors on all important roads leading out of the area"—"an area of which Philadelphia is the centre and which contains 1,500 nurseries and growers of ornamental plants".

These three sketches are given to show how complex and difficult is the control of certain imported insect pests, when uncontrolled by their natural enemies, while their commercial importance is colossal. In his Presidential Address to the American Association for the Advancement of Science, Dr. Howard took as his subject "The war against the Insects". In his concluding summary he says: "Few people realize the critical position which exists at the present time. Man is the dominant type on this terrestrial body; he has subdued or turned to his own use nearly all living creatures. There still remain, however, the bacteria and protozoa that carry disease and the enormous forces of injurious insects which attack him from every point and which constitute to-day his greatest rivals in the control of nature. They threaten his life daily; they shorten his food supplies both in his crops when growing and when stored, in his meat animals, in his comfort, in his clothing and in countless other ways. They constitute a much older geological type, and it is a type which had persisted for countless years before he made his appearance—persistence due to characteristics which he does not possess and cannot acquire—rapidity of production, power of concealment, a defensive armour and many other factors. With all this in view, it will be necessary for the human species to bring this great group of insects under control, and to do this will demand the services of skilled biologists, thousands of them".

In 1915 Sir Harry Johnston wrote an article in the *Nineteenth Century* entitled "The Next War: Man *versus* Insects", and in 1919 Colonel W. Glen Liston used the same title in his address as president of the Medical Research Section of the Indian Science Congress held at Calcutta. In March, 1925, *Harper's Magazine* has a very well written paper by W. A. Du Puy under the title "The Insects are winning", a Report on the Thousand Year War in which much of the above evidence is cited.

Webster says: "It costs the American farmer more to feed his insects than it does to educate his children". The average damage done by insects to crops in the United States was conservatively estimated by Riley to be $300,000,000 (about £60,000,000). A recent estimate of the loss from forest insect depredations is not less than $100,000,000. The common schools of the country cost in 1902 $235,000,000. Higher education cost $50,000,000, making the total cost of education considerably less than the farmers lost from insect ravages.

In this connection there is a striking paragraph of Maeterlink quoted by Howard: "The insect does not belong to our world. The other animals, even the plants, in spite of their mute existence and the great secrets which they nourish do not seem wholly strangers to us. They surprise us, even make us marvel, but they fail to overthrow our basic concepts. The insect on the other hand, brings with him something that does not belong to the customs, the morale, the psychology of our globe. One would say that it comes from another planet, more monstrous, more insensate, more atrocious, more infernal than ours. It seizes upon life with an authority and a fecundity which nothing equals here below; we cannot grasp the idea that it is a thought of that Nature of which we flatter ourselves that we are the favourite children. There is, without doubt, with this amazement and this incomprehension, and I know not what of instinctive and profound inquietude inspired by these creatures, so incomparably

better armed, better equipped than ourselves, these compressions of energy and activity which are our most mysterious enemies, our rivals in these latter hours, and *perhaps our successors*". (Italics mine.)

A few decades ago everywhere in Europe, America and even in Australia people picked their apples and peaches from their own back yard. Pests like the San Jose or Indian wax scale no longer allow this. The small grower cannot or will not use the scientific methods that alone enable the modern orchardist to get a crop and folks must go to the fruit shop for their supply of vitamines—at a price in Australia determined by the fruit rings.

Now Australia is actually greater in area than the United States; with a larger proportion of its extent lying within the tropics, together with alpine and temperate climates over a large southern section; it has a sparse population of which one-half is contained within a few cities, so that its agricultural population is very thinly scattered. It thus provides ideal conditions for pest invasions, from other lands—and we have them! Australia is to-day confronted with economic disasters of the first magnitude, in at least four great invasions, of which two at least involve skilled entomological treatment, while the other two involve biological problems of analogous nature. I do not know their comparative commercial importance, but I am sure that the bill for rabbit netting alone must be a question of millions of pounds. Now while I do not claim the rabbit as an insect, its check is attempted chiefly by poison, while its faunal enemies are the fox, the domestic cat "gone wild" and the eagle, each of which is the enemy also of the insectivorous birds—while the poison cart's effect on the avifauna is notorious. Thus the invasion of three European mammals is on the side of the Insects. For the devastations caused by the domestic cat "gone bush", see *The Emu*, Jan., 1924, pp. 175-9. Mr. Gerald Hill reports them N.W. of Kimberley, between Oodnadatta and Alice Springs, through the MacDonnell Ranges, the Macarthur and Roper Rivers. Mr. R. T. Maurice's report, printed by the South Australian Government, says of the Expedition between Fowler's Bay and Cambridge Gulf, "more domestic cats than rabbits were seen". The Wilkins Expedition reported wild cats as troublesome. At Mildura they attack poultry, Mrs. Hobler (one of the well-known Barnard naturalist family and whose recent decease I was grieved to note) wrote of them in Central Queensland, where they have almost exterminated the Squatter Pigeon.

The SECOND great pest invasion is vegetable, the prickly pear. Of this appalling pest, Bulletin No. 12 of the Commonwealth Institute of Science and Industry stated in 1919 that it occupied some 23,000,000 acres in Queensland and New South Wales and was spreading at the rate of a million acres a year. A Board appointed to consider the steps necessary to fight it concluded that while mechanical and chemical agents were effective on small areas, the only checks on a large scale that could be economically employed must be biological. Accordingly two laboratories in Queensland and one in New South Wales, besides one at Uvalde, Texas, have been established for the investigation and testing of insects, bacteria and fungi which are the natural enemies of the Opuntias, after these parasites and pear diseases had been studied by the Harvey Johnston-Tryon mission and later by Mr. W. B. Alexander in various parts of North and South America. The last mentioned gentleman has during the last few months published a most valuable report—Bulletin No. 29 of the Institute of Science and Industry—giving the special history of the work of the Prickly Pear Board during the four years of its existence. The funds available have been £8,000 per

annum, of which £4,000 was supplied by the Federal and £2,000 each by the Queensland and New South Wales Governments. This has been (or is likely to be) increased this year to £12,000. Some 52 insects have been studied, besides a large number of fungi, bacteria and two red spiders—no less than four species of insects new to science being discovered in the investigation. Bulletin 29 carries the work to the end of 1924 since when I learn from Mr. Alexander many supplementary details—including a large number of insects besides the above—have been investigated. The general results so far are somewhat as follows. While no wholesale destruction of pear has been accomplished, it is now possible to walk freely through certain paddocks near Dulacca, where the cochineal *Dactylopius tomentosus* was liberated first in 1921, which were densely infested and impassable then. Also there was no recorded increase of infested area in 1925 in Queensland. That while *D. tomentosus* and the Red Spider *Tetranychus opuntiae* were the most destructive to pear organism yet observed, many other insects, notably certain moth caterpillars and borer beetles, so weakened the plants as to make the cochineal attacks more effective. The most disappointing detail of Mr. Alexander's report lies in the fact that besides the three worst Opuntias so far known as pests, of which one (*O. monacantha*) has been almost exterminated by *Dactylopius indicus*, a fourth species, *O. aurantiaca* (known as the Jointed Cactus), a serious pest in South Africa, is making rapid headway in South Queensland and Northern New South Wales and is actually *impervious to the attacks of any of the imported parasites* that do attack the other pears. I have gathered from longer and more confidential conversations with Mr. Alexander the immense importance of the control of this work by not one but by a *body* of trained biologists, who should, after consultation, direct researches on the many branches, biological and chemical, that are associated with this great national work. For example any bacteriologist is aware of the necessity for all the precautions usual in his laboratory in dealing with an imported organism and that a bush laboratory fitted for breeding and testing insects is a quite unfit place for the study of these, as also of fungoid growths.

The THIRD great invasion is that of the Cattle-tick. This, while outside the insect region, entails the similar study of life history, and a cooperation of scientific work analagous to the work of entomology. In 1924 the Commonwealth, New South Wales and Queensland Governments agreed to contribute £174,000 towards the eradication of this pest.

The FOURTH is the sheep blow-fly (or flies) for three species appear chiefly responsible. Here the valuable work done by Messrs. W. W. and J. L. Froggatt has pointed the way and devised checks, but the added labour and cost of providing curative and precautionary measures to-day forms perhaps the greatest and most onerous burden to the pastoralist. There is here also need for much research, not only in the direct action required, but on secondary matters that arise in research, often leading to important discoveries. No scientific stone should be left unturned by way of helping our great staple industry. Mr. Froggatt stated the direct loss in 1912 from the blowflies as little less than a *million* pounds. I should here like to congratulate Mr. Gurney and his staff at the Entomological Branch of the Department of Agriculture on the valuable experiments recently carried out to determine the range of flight of certain blowflies.

The Locust and Grasshopper plagues fall little short of the above. The fight between man and insect thus may be traced for some 2,000 years. A report on the modern war against the locust is given in *Nature*, Jan. 1925, by the fine

entomological writer Dr. Imms, "Locust Problems and its International Control", in which I find the following:

"In 1908 in the Transvaal the damage to crops amounted to £1,000,000. In 1915 in Argentine 20 tons of eggs were collected in one month. In 1920 in S. France 12-30 millions of locusts were destroyed daily. The fact that all lands between Lat. 20°-40° N. and Lat. 15°-45° S. were subject to plagues of locusts demanded international organization and the '*League of Nations*' would be asked to lend authority for concerted action—since locusts travel up to 300 miles per day. In 1920 thirty-five countries signed a convention at the Rome Conference with the International Agricultural Institute as the headquarters of 'International Locust Information Bureau'."

Of the methods of control they report:

(1) The natural agents, parasitic and bacterial are insufficiently explored.

(2) Mechanical methods inadequate.

(3) Physical methods. Fire and the "flammen werfen" are used in Algeria. Poison gas is not a success but arsenate of soda was most satisfactory.

I will not weary you with further details of the insect foes with which our slender entomological departments are fighting. My object is rather to call attention to the immense importance and need of more and more and more scientific workers in our great country and the present inadequacy of trained workers. It is but a bald statement of fact that the Island of Hawaii under United States rule employs more trained entomologists than the whole of Australia and pays them, especially the leaders, at a more generous rate. Some of these we welcomed at the recent Pan-Pacific Science Congress. Three of their most eminent men have also visited Australia in the course of special research. Thus Mr. F. Muir has introduced the Australian Carab-beetle (*Drypta mastersi*) as a destroyer of sugar-cane grubs. Mr. Pemberton has investigated the Australian Fern Weevils (*Syagrius*) and their parasites as a check to the devastation of the Hawaiian ferns over their water catchment areas. He incidentally introduced into Hawaii the Blastophaga wasp that fertilizes the Moreton Bay Fig (hitherto not producing seed in the island and used to replace much of the lost forest areas). The similar introduction of another *Blastophaga* into California has improved the flavour of the Smyrna fig by its fertilization. A third visitor, Mr. J. F. Illingworth (Research Associate of Entomology of the Bernice Pauahi Bishop Museum, Honolulu), while in Queensland, investigated the root disease of the Queensland bananas and showed it to be due to certain Nematode worms. At the same time the Banana Industry in New South Wales has been practically ruined by the incidence of the "Bunchy Top" disease, for which I believe I am correct in stating no effective remedy has yet been found nor (as I was informed less than 12 months ago by an expert) even its nature discovered.

To quote Dr. Howard again: "Any one of the many discoveries being made in physics, chemistry or other sciences may touch or may be made to touch our investigations looking towards the control of insects, e.g. Professor C. K. Brain in S. Africa announces the adaptation of certain radio principles, in which by the use of microphones the presence of insects may be determined, not only of wood-boring insects, in wood, but of insects in stored grains". Again of *insect physiology* he says truly, "this is the largest as it is surely the most important of the comparatively unexplored fields in entomology". "To understand their reactions, to explain their tropisms we must know how they communicate, how they hear, see, digest their food and scores of other things".

To the working entomologist in Australia two great British Institutions are of exceeding interest and assistance: (1) The British Museum of Natural History —the central collecting house of the world, where every enquirer is met with efficient service and unlimited courtesy. In my two visits in 1907 and 1922 it was a great pleasure to meet those whom I had known only by correspondence, to find a personal courtesy that was but a natural corollary to their letters. This cooperation is indispensable towards obtaining accurate determinations. To the *Nineteenth Century* for November, 1924, is contributed an article by Sir Frederick E. Kenyon on this branch of the British Museum, for a short extract from which I must ask your kindly indulgence: "Apart from the abstract needs of scientific research, the full bearing of which can only be appreciated by years of study and the accumulation of materials, it has of late been increasingly made evident that the welfare of mankind is in many ways dependent on a fuller acquaintance with the world of nature of which Man is only a part. Entomology in particular is now recognized as being a study essential for the science of health and disease and for the economic utilization of many of the resources of nature. *A whole department of economic entomology has grown up within the last few years and still needs immeasurable increase in materials and in students—likewise a great increase of the trained and specialist staff, with adequate time for their work*".

The second great British Institution referred to is the Imperial Bureau of Entomology so ably directed by Dr. Guy Marshall, C.M.G., F.R.S., whom we welcomed as Chairman of the Entomological Section of the Pan-Pacific Science Congress.

This Bureau is subsidized by the Imperial, Dominion and Colonial Governments to the extent of about £12,000 per annum, Australia contributing £1,000 per annum (Commonwealth £400, States £600). It issues two important and valuable publications, the monthly *Review of Applied Entomology* and the illustrated quarterly *Bulletin of Entomological Research*, which are models of modern scientific journalism, containing a wide purview of work—economic and medicinal —throughout the Empire.

Under the auspices of, and initiated by, this Bureau, two Imperial Entomological Conferences have been held, the first in June, 1920, the second in June, 1925, at Burlington House, London. No less than 18 Oversea Governments besides Egypt were represented by entomological delegates, Australia being represented only by two political agents—Sir Joseph Cook for the Commonwealth and the Hon. H. P. Colebatch, C.M.G., for Western Australia—New South Wales and the other four States thus being unrepresented. I should like to think that the third Conference to take place in 1930 will contain Australian scientific delegates from each State, who will give and receive those reciprocal advantages so obviously associated with such Conferences. The Conference recommended by resolution that from time to time meetings of the entomologists, mycologists and other scientific officers for joint discussion of their local problems should be held in each of the Dominions. In regard to this resolution I would note that the biennial Pan-Pacific Science Congress to some extent meets this case. A very useful complement to this would be a Conference of the Australian entomologists, mycologists and other scientific officers in the alternate years in which the Pan-Pacific Congress does not meet. The Imperial Bureau also proposes to arrange for the export to Oversea Governments of beneficial parasites. (Parenthetically it may be observed that the old world owes us some beneficent balance to the rabbit, the sparrow, the rat and the flea.)

The *Third* International Congress of Entomology was held at Zurich (July 20, 1925). The first was held at Brussels, the second at Oxford, while the third had been proposed at Vienna in 1914—postponed for obvious reasons. At Zurich some 200 entomologists were present, 60 from Britain, but Australia was unrepresented. There is no need in this Society to stress the importance and value of such a Congress, the international nature of entomology having already been referred to in this address.

Amidst the stream of modern literature on entomology three works stand out as important textbooks—the one English, the other two American. The first by Dr. A. D. Imms, "A general textbook of Entomology", breaks much new ground and is of special value in the advanced treatment of anatomy, physiology and classification of insects. The second, by Professor Folsom of the University of Illinois, is entitled "Entomology with reference to its Biological and Economic Aspect", with a chapter on Insect Ecology of great interest; while the palaeo-entomology is very well done. The third, perhaps most important of all, I have not had the opportunity to see but, from its high press notices I gather that "it is a starting point in the NEW ENTOMOLOGY, just as the older entomologists took Westwood's famous "Introduction" and later Sharp's "Insecta". This is a work of 1,000 pages by the veteran Comstock called "Introduction to Entomology" (1925). Another recent book of interest is "The anatomy and physiology of the Honey Bee", by R. E. Snodgrass (N. York), from which we learn that there is no evidence that "bees hear", "the fore plates of the last 8 segments of antennae are the special organs of smell".

It is encouraging to note certain signs of advance in our own land. A larger number of Australian entomologists are entering various fields of work to supplement the older workers. Of the latter Dr. Waterhouse and G. Lyell have produced a classic on our Butterflies, which is being completed by a further study of life-histories. Froggatt's "Insects of Australia" has sold out its early edition and the demand for it will doubtless soon elicit another edition. Dr. Tillyard's "Insects of Australia and New Zealand", now in the press, marks an epoch in the new Entomology by its thoroughness of scholarly detail. A. M. Lea has made a record for the number of described Coleoptera, besides a considerable output of economic and other work. T. G. Sloane's scholarly studies of our Carabidae are widely known outside Australia. A. H. Elston in South Australia and F. E. Wilson in Victoria have also entered the lists, the former commencing a useful and difficult task of clearing up the family Elateridae. Gerald F. Hill, naturalist and explorer, now entomologist to the National Museum, Melbourne, has added greatly to our knowledge of the destructive termites, besides other things, including an important paper on the "Distribution of Anopheline mosquitoes in the Australian Region". J. Clark of Perth has made his mark in a field too long left to the outside investigator, the important and numerous family, the Ants. H. Hacker and Girault have made the Queensland Museum the repository of a great deal of our knowledge of our wasp Hymenoptera, so important in parasitology. The former has, besides remaking the Queensland Museum collection of insects, also done excellent microphotography on the life-histories of a wide range of insects. In the extensive range, the Diptera, great advance has been made recently chiefly through the researches of Dr. E. W. Ferguson, G. H. Hardy and Dr. Mackerras, Professor Harvey Johnston and Miss Vera Irwin Smith with the specialist aid of J. R. Malloch and Professor Bezzi. In the Orthoptera, Dr. Eland Shaw has played an effective lone hand, while Dr. Tillyard's studies on Odonata, Neuroptera and the miscellaneous insects of the smaller Orders are models of their kind. The

days of our tutelage to exotic scientific authority are over, though science must ever be cooperative and interpenetrative.

Two advantages occur through the systematic work of our own men:

(1) The work is done largely by men who combine field observation with literary knowledge of the subject, (2) the types remain in Australia for future reference by students of the subject. To this may be added the better supply of technical literature now available, due to the greater demand. The first of these points carries with it the following obvious desiderata: The exact habitat of a species is known, instead of the vague label Australia or "New Holland" of our early authorities; the extent of variation, sexual dimorphism, ecology, life-histories, habits, food plants and other important details are being gradually elicited.

One important step in advance deserves special notice. The University of Sydney has lately added a permanent lecturer in Entomology to its Zoological staff, and may be congratulated on the selection of an enthusiastic and methodical worker in Mr. A. J. Nicholson, M.Sc., whose excellent beginnings both as teacher and field worker lead us to expect much more in the future. Forestry has also utilized our veteran entomologist, Mr. W. W. Froggatt, in the investigation of borers—a large subject in itself, but coupled with the work of remedial measures must require a vastly larger staff than has yet been dreamed of in our departmental philosophy for effective treatment. One often hears folk in town and country speak of the "borer" as if a single species were responsible for the vast damage to timber, posts and fences, whereas many hundreds of species in many families of Coleoptera, besides other insects, need careful study in this connection. It is also a good sign that merchants and builders interested in the commercial side are beginning to be aware of the value of scientific work in their respective branches.

Still I would repeat there is great need for serious effort in tackling the greater problems involved in economic biology. There have been rumours of a Federal Department of Entomology. It is high time that the Central Government followed, although from afar, the great example of our American cousin and, while really helping the settler and the nation, also opened to our students careers of great usefulness and unlimited fields of research. The wide nature of the economic problems that are involved in dealing with our primary pests points to a wide range of research and what might be called a Federal Bureau of Biology could fitly undertake research on the greater questions, leaving the ordinary orchard and more local pests to the State Department of Agriculture, a more than sufficient field of labour for the present hardworked staffs. Whether such a Bureau should be part of the Commonwealth Institute of Science and Industry, when and if sufficient funds are available, is a matter of detail. Its success, however, will absolutely depend on its direction by a highly qualified biologist and on the nature and extent of its staff. Such a Director should be remote from political control. Whatever its constitution, the urgent and important nature of these national catastrophes demands the permanent services of an administrative and executive staff directed by skilled biologists. Since Pasteur, no applied biology comparable to his many sided work has been accomplished by any one man. Australia could find work to-day for several Pasteurs. Says Dr. Howard "In the study of Natural Control, insect pathology, a largely neglected field, must have more workers". "There are great gaps to be filled in our knowledge of the forms of parasitism in which protozoa, bacteria, fungi, helminths and filterable viruses are concerned".

A further field for research is the important part played by insects in the dissemination of the virus disease of plants. Two South African biologists (H. H. Storey and A. M. Bottomley) have demonstrated the ability of *Aphis leguminosae* to transmit the *rosette disease* to the peanut, a disease which causes "bunching" and other abnormal growths in which no seed is set and the yield greatly reduced. This suggests a research into our Banana disease, to which reference has already been made.

Medicinal Entomology may well be left to my successor, the highest existing Australian authority on the subject.

I have now to acknowledge gratefully the high honour you have done me in your selection as President for the past year and to express my thanks to my colleagues on the Council for their unfailing support and courtesy during that period.

Dr. G. A. Waterhouse, Hon. Treasurer, presented the balance sheets for the year 1925, prepared by Mr. J. H. Campbell and duly signed by the Auditor, Mr. F. H. Rayment, F.C.P.A., Incorporated Accountant; and he moved that they be received and adopted, which was carried unanimously.

No nominations of other Candidates having been received, the President declared the following elections for the ensuing Session to be duly made:—

President: E. W. Ferguson, M.B., Ch.M.

Members of Council: E. C. Andrews, B.A., F.G.S., E. Cheel, T. Storie Dixson, M.B., Ch.M., J. J. Fletcher, M.A., B.Sc., G. M. Goldfinch and A. F. Basset Hull.

Auditor: F. H. Rayment, F.C.P.A.

A cordial vote of thanks to the retiring President was carried by acclamation.

Linnean Society of New South Wales

GENERAL ACCOUNT. Balance Sheet at 31st December, 1925.

LIABILITIES.

	£ s. d.	£ s. d.
Capital: Amount received from Sir Wm. Macleay during his lifetime	14,000 0 0	
Further sum bequeathed by his will	6,000 0 0	
		20,000 0 0
Contingencies Reserve		7,700 0 0
Income A/c. at 31st December, 1925		170 1 10
Commercial Banking Coy. of Sydney, Ltd.		400 10 5
		£28,270 12 3

ASSETS.

	£ s. d.	£ s. d.
Society's Freehold		11,000 0 0
Investments: Commonwealth Loans ..	£9,280 0 0	
Loans on Mortgage ..	7,980 12 3	
		17,260 12 3
Cash in hand		10 0 0
		£28,270 12 3

INCOME ACCOUNT. Year Ended 31st December, 1925.

	£ s. d.	£ s. d.
To Salaries, Wages and Allowance		1,143 0 0
„ Printing Publications	£551 10 9	
„ Illustrations	196 16 6	
		748 7 3
„ Rates and Insurance		315 2 6
„ Postage	£56 19 11	
„ Audit	7 7 0	
„ Printing and Stationery	18 16 0	
„ Expenses	35 9 8	
„ Petty Cash	41 14 1	
„ Bank Expenses	1 11 5	
		161 18 1
„ Legal Expenses (R.P. Act)		80 2 4
„ Land Sales Expenses		227 5 6
„ Furniture and Repairs		97 12 2
„ Library and Bookbinding		80 10 6
„ Appropriation: Contingencies Reserve		56 0 0
„ Balance to 1926		170 1 10
		£3,080 0 2

	£ s. d.	£ s. d.
By Balance from 1924		77 18 7
„ Subscriptions: 1925	£152 5 0	
Arrears	12 12 0	
In Advance	3 3 0	
		168 0 0
„ Entrance Fees		13 13 0
„ Interest		863 5 6
„ Rents		664 10 5
„ Sales (including 100 copies of Proceedings purchased by Govt. of N. S. Wales)		194 1 2
„ Fellowships A/c. (surplus income transferred) ..		1,098 11 6
		£3,080 0 2

Examined and found correct. Securities produced.

F. H. RAYMENT, F.C.P.A.,
Auditor.

2nd February, 1926.

Sydney, 14th January, 1926.

J. H. CAMPBELL,
Hon. Treasurer.

LINNEAN MACLEAY FELLOWSHIPS ACCOUNT.

BALANCE SHEET at 31st December, 1925.

LIABILITIES.	£	s.	d.	ASSETS.	£	s.	d.
Amount bequeathed by Sir Wm. Macleay	35,000	0	0	Commonwealth Loans	7,920	0	0
Surplus Income capitalised..	9,500	0	0	Loans on Mortgage	36,580	0	0
	£44,500	0	0		£44,500	0	0

INCOME ACCOUNT. Year Ended 31st December, 1925.

	£	s.	d.		£	s.	d.
To Salaries of Linnean Macleay Fellows	1,566	13	4	By Interest	2,797	12	6
„ Fellows' Subsidies	99	1	0				
„ Capital A/c.	33	6	8				
„ General A/c.	1,098	11	6				
	£2,797	12	6		£2,797	12	6

Examined and found correct. Securities produced.

F. H. RAYMENT, F.C.P.A.,
Auditor.

2nd February, 1926.

J. H. CAMPBELL,
Hon. Treasurer.

Sydney, 14th January, 1926.

BACTERIOLOGY ACCOUNT.

BALANCE SHEET at 31st December, 1925.

LIABILITIES.	£	s.	d.	ASSETS.				£	s.	d.
Amount bequeathed by Sir Wm. Macleay	12,000	0	0	Commonwealth Loans				14,800	0	0
Accumulated Income capitalised	2,000	0	0	Cash: Commercial Banking Coy.	£1	13	5			
Income A/c. at 31st December, 1925	926	17	9	Government Savings Bank	119	4	4			
				In hand	6	0	0			
								126	17	9
	£14,926	17	9					£14,926	17	9

INCOME ACCOUNT. Year Ended 31st December, 1925.

	£	s.	d.		£	s.	d.
To Salary and Wages	604	0	0	By Balance from 1924	928	11	5
„ Expenses	15	11	2	„ Interest	740	11	2
„ Apparatus and Chemicals	116	14	10	„ Tuition Fees	3	6	8
„ Petty Cash	9	5	6				
„ Balance to 1926	926	17	9				
	£1,672	9	3		£1,672	9	3

Examined and found correct. Securities produced.
F. H. RAYMENT, F.C.P.A.,
Auditor.

2nd February, 1926.

Sydney, 14th January, 1926.

J. H. CAMPBELL,
Hon. Treasurer.

ABSTRACT OF PROCEEDINGS

ORDINARY MONTHLY MEETING.

31st March, 1926.

Dr. E. W. Ferguson, M.B., Ch.M., President, in the Chair.

The Donations and Exchanges received since the previous Monthly Meeting (25th November, 1925) amounting to 65 Vols., 466 Parts or Nos., 55 Bulletins, 16 Reports and 58 Pamphlets, received from 163 Societies and Institutions and 3 private donors were laid upon the table.

PAPERS READ.

1. Notes on Australian Diptera. No. viii. By J. R. Malloch. *(Communicated by Dr. E. W. Ferguson.)*

2. Upper Permian Insects of New South Wales. Part i. Introduction and the Order Hemiptera. By R. J. Tillyard, M.A., D.Sc., F.R.S.

3. The Australian Syrphidae in the Bishop Museum (Diptera). By C. H. Curran and E. H. Bryan, Jr. *(Communicated by Dr. E. W. Ferguson.)*

4. Gasteromycetes of Australasia. iv. Species of the Genus *Geaster*. By G. H. Cunningham.

ORDINARY MONTHLY MEETING.

28th April, 1926.

Dr. E. W. Ferguson, President, in the Chair.

Mr. J. Freeman, Armidale, Miss Lesley D. Hall, Balmain East, Mr. R. W. Mungomery, Bundaberg, Queensland, Mr. G. A. V. Stanley, Randwick, Mr. A. S. Waterer, Haberfield, Mr. G. P. Whitley, Australian Museum, Sydney, and Miss Lucy M. Wood, Galston, were elected Ordinary Members of the Society.

The President announced that Messrs. J. J. Fletcher, M.A., B.Sc., A. F. Basset Hull, R. H. Cambage, C.B.E., F.L.S., and H. J. Carter, B.A., F.E.S., had been elected Vice-Presidents; and Dr. G. A. Waterhouse, Hon. Treasurer for the Session 1926-27; also that Mr. A. H. S. Lucas, M.A., B.Sc., had been elected a Member of Council in place of Mr. J. H. Campbell.

An invitation was received from the Wild Life Preservation Society of Australia for members to be present at the Annual Meeting to be held at the Royal Society's Hall on 18th May.

The Donations and Exchanges received since the previous Monthly Meeting (31st March, 1926) amounting to 19 Vols., 111 Parts or Nos., 2 Bulletins, 1 Report and 1 Pamphlet, received from 53 Societies and Institutions and 2 private donors were laid upon the table.

PAPERS READ.

1. An Ecological Study of the Flora of Mount Wilson. Part iii. The Vegetation of the Valleys. By J. McLuckie, M.A., D.Sc., and A. H. K. Petrie, B.Sc.

2. Preliminary Note on Branch Fall in the Coniferales. By C. Barnard, B.Sc.

3. Revision of the Australasian Species of *Anilara* (Buprestidae) and *Helmis* (Dryopidae), with Notes, and Descriptions of other Australian Coleoptera. By H. J. Carter, B.A., F.E.S.

NOTES AND EXHIBITS.

Mr. D. G. Stead exhibited a large collection of the pelagic larvae and later stages of the young of Squillidae taken by him in waters of the Malay Peninsula and of Sumatra. He described also the great density of pelagic life in those waters and the brilliancy of the phosphorescence occasioned thereby.

Mr. Stead also exhibited a herbarium specimen of *Heterodendron oleaefolium* ("Emu Bush") taken from a clump of the trees lying between Narrandera and Yenda, and stated that on 1st March he, in company with Stock Inspector Yeomans, had seen a flock of crows calculated to contain not less than 1,000 individuals, as well as several thousands of starlings, all of which were feeding on the berries of the plant.

Mr. W. W. Froggatt exhibited specimens of the Red Gum Leaf Moth (*Nola metallopa* Walk.) and stated that last February a patch of about 1,000 acres of the Moira State Forest, N.S.W., along the Murray River, was so thickly infested with the larvae of these moths that every leaf on every tree turned brown, the surface being gnawed off, and the whole looked like a dead forest. A much larger area on the Victorian side of the Murray River was damaged in the same manner.

Mr. E. Cheel exhibited specimens showing extreme variation in the size of the leaves from those of the normal form of "Citron-scented tea-tree" (*Leptospermum citratum* Cheel). Two plants raised from the same supply of seeds collected at Copmanhurst (type locality), and grown under similar conditions as 28 other plants, developed leaves fully twice as broad and proportionately longer, the flowers also being nearly twice the size of those of the normal plants. The occurrence of this development is noteworthy, and of special interest to taxonomists, as similar developments may occur in nature.

Mr. J. R. Kinghorn exhibited, on behalf of an engineer of the Sydney Harbour Trust, a perfect specimen, some 15 inches in length, of a ship worm *Teredo* sp., taken from a pile between No. 2 and No. 3 Wharves, on the east side of Circular Quay, Sydney, N.S.W.

The Secretary read a letter from Professor R. Broom, Corresponding Member, referring to the exhibit of a specimen of *Coenolestes fuliginosa* by Mr. Troughton at the November meeting, 1925. Professor Broom points out that in the PROCEEDINGS, 1898 (p. 74) he expressed doubt as to *Coenolestes* being a diprotodont; he also quotes subsequent work on this subject and concludes: "We can thus be quite sure that *Coenolestes* is merely a modification of the American Polyprotodonts with no near affinities with Diprotodonts".

The Secretary exhibited a specimen of Desert Sand from Trimen, between Boolabooka and Menindie, forwarded by Mr. C. Thackeray. This is a sample of the "moving sand" encountered on the Condobolin-Broken Hill railway, which has caused considerable trouble in the construction of the line.

ORDINARY MONTHLY MEETING.

26th May, 1926.

Dr. E. W. Ferguson, President, in the Chair.

The President referred to the very great loss the Society had sustained by the deaths of Miss E. E. Chase, Sir Hugh Dixson and Mr. J. J. Fletcher, and announced that an expression of members' sympathy had been forwarded to Mrs. Chase, Mr. William Dixson and Mrs. Fletcher.

It was unanimously resolved "that the members of the Society present desire to place on record their profound sorrow at the death of Mr. J. J. Fletcher and their high appreciation of the value of his services to the Society as President (1919-21), member of Council (1883-1926) and Secretary (1886-1919), to Australian Science by his original contributions, and to scientific workers by his willingness at all times to give them the benefit of his advice and assistance."

Mr. Daniel Frederick Cooksey, 83 Fawcett Street, Mayfield, N.S.W., and Dr. Frederick William Whitehouse, M.Sc., F.G.S., Queensland Geological Survey, Brisbane, were elected Ordinary Members of the Society.

The President expressed congratulations of members to Professor Wilson, Honorary Member, on the announcement of the intention of the University of Edinburgh to confer on him the degree of LL.D., honoris causa.

The Donations and Exchanges received since the previous Monthly Meeting (28th April, 1926) amounting to 20 Vols., 140 Parts or Nos., 3 Bulletins and 5 Reports, received from 67 Societies and Institutions and 2 private donors were laid upon the table.

PAPERS READ.

1. Further Notes on the Genus *Pterostylis*. By Rev. H. M. R. Rupp. (*Communicated by Mr. E. Cheel.*)

2. Revision of Australian Syrphidae. Part 1. By E. W. Ferguson, M.B., Ch.M., D.P.H.

3. An Experimental Study of the Development of the Limbs of the Chick. By P. D. F. Murray, B.Sc., Linnean Macleay Fellow of the Society in Zoology.

4. The Influence of certain Colloids upon Fermentation. Part iii. Fuller's Earth and Aeration in the Alcoholic Fermentation. By R. Greig-Smith, D.Sc., Macleay Bacteriologist to the Society.

NOTES AND EXHIBITS.

Mr. David G. Stead exhibited two examples of an extraordinarily large variety of banana obtained by him at a Malay village market at Selat Panjang, Sumatra. This variety of banana commonly reaches a length of eighteen inches and a diameter of four inches, and is known by the Malay name of pisang raja. It is used mostly in the making of curries. A bunch of twenty of this great fruit was purchased for ten cents (Straits currency)—about 2½d.

Dr. G. A. Waterhouse exhibited a remarkable aberrant butterfly from Dutch New Guinea belonging to the genus *Taenaris*. The underside of the right hindwing shows the usual two large ringed ocelli; these are entirely wanting on the underside of the left hindwing, which, except that it is slightly smaller than the right, is otherwise normal.

Mr. T. C. Roughley exhibited a "King" prawn (*Peneus plebejus*), eight inches long, dissected to show the well developed ovary, and also photographs and a drawing of the dissected prawn. This specimen was obtained with numbers of

others during February, 1926, on a kelp-covered bottom in twelve fathoms of water off Clifton Gardens, Port Jackson, in a prawn net exactly similar to a miniature otter trawl, which was towed behind a launch. Although "King" prawns abound in the waters of Port Jackson during the summer months, and large numbers are captured for the market, this is the first occasion that any have been seen with mature roes. Although numbers of males were captured at the same time, none was found with well developed testes.

The Secretary communicated the information received from Mr. Scully, of Dee Why, that the specimen described by Dr. Tillyard (PROCEEDINGS, 1925, p. 374) as "a remarkable new insect wing which has recently been discovered . . . at Beacon Hill, near Dee Why . . ." was actually found during September, 1912, and had been lying in Mr. Scully's collection for more than ten years before it came under the notice of Professor Sir Edgeworth David.

The Australian Forest League will hold an excursion to the Dalrymple Hay Demonstration Forest at Pymble on Saturday, 12th June, 1926.

ORDINARY MONTHLY MEETING.

30th JUNE, 1926.

Dr. E. W. Ferguson, President, in the Chair.

The President referred to the death of Mr. H. E. Finckh, who had been a member of the Society since 1908.

The President offered congratulations to Mr. E. C. Andrews on the invitation extended to him to deliver the Silliman Lectures at Yale during 1927.

Mr. Kenneth J. F. Branch, B.Sc., 99 North Steyne, Manly, and Mr. James Hardie Buzacott, Meringa (Private Bag), via Cairns, Queensland, were elected Ordinary Members of the Society.

Acknowledgments of the Society's sympathy were received from Mrs. Fletcher, Mrs. and Miss Chase, the family of the late Sir Hugh Dixson, and Mrs. Finckh and daughters.

The Donations and Exchanges received since the previous Monthly Meeting (26th May, 1926) amounting to 24 Vols., 94 Parts or Nos., 21 Bulletins, 2 Reports and 25 Pamphlets, received from 59 Societies and Institutions and 4 private donors were laid upon the table.

PAPERS READ.

1. Upper Permian Insects of New South Wales. Part ii. The Orders Mecoptera, Paramecoptera and Neuroptera. By R. J. Tillyard, M.A., D.Sc., F.R.S.

2. New Species of Australian Proctotrypoidea, with Revisional Notes. By A. P. Dodd.

3. A New Classification of Australian Robberflies belonging to the Subfamily Dasypogoninae (Diptera, Asilidae). By G. H. Hardy.

4. Contributions to the Cytology and Phylogeny of the Siphonaceous Algae. 2. Oogenesis and Spermatogenesis in *Vaucheria geminata*. By May M. Williams, M.Sc., Linnean Macleay Fellow of the Society in Botany.

NOTES AND EXHIBITS.

Mr. David G. Stead exhibited three specimens of Malay Tambourines, obtained by him in the Malay city of Palembang (Sumatra). The "tympanum" of each tambourine is made from the skin of a species of Stingray (*Dasyatis sephen*), known under the Malay name of Ikan Pari beting. Thousands of these instruments

are made in Palembang and are exported to other places. They are used both for individual dancing and in the "Ronggeng".

Mr. W. W. Froggatt exhibited a series of specimens of the Hoop pine Buprestid Beetle *Prosophoris aurantiopicta* L. & G., and *P. aurantiopicta* var. *moesta* Carter, showing the variations in colouration. The larvae of these beetles feed on the sapwood of dead stumps of felled hoop pines in the Dorrigo forests. In a suitable stump the exhibitor has taken dozens in all stages of development during January. In all cases they are very close to the surface and he has never cut out a spotted specimen. All the spotted specimens have been found in rooms where they had come out of the hoop-pine floors and generally cut their way through the linoleum when emerging. In the fact that they must be deeper in the wood when living in flooring boards or that their development is retarded, the varied colouration may possibly be accounted for. The golden yellow spots vary from two to sixteen.

Mr. A. H. S. Lucas exhibited portion of a small gathering of algae from the lagoon at Nukualofa, Tonga, forwarded by Mrs. Wood; the following were received in the collection: *Sargassum desvauxii* (Mest.) Ag. and *S. polycystum* Ag. (both recorded from Australia), *Hormosira articulata* (Forsk.) Zan. (the exhibitor has this from New Caledonia and also gathered it in Port Stephens. It has not been recorded before from Tonga), *Padina fraseri* (Grev.) J. Ag., *Hydroclathrus cancellatus* Bory., *Acanthophora orientalis* J. Ag., *Hypnea seticulosa* J. Ag., *Actinotrichia rigida* (Lamx.) Decne., *Ulva lactuca* L., *Boodlea coacta* Murray, *Caulerpa freycineti* Ag., *Halimeda opuntia* (L.) Lamx.

ORDINARY MONTHLY MEETING.

28th July, 1926.

Dr. E. W. Ferguson, President in the Chair.

A letter was received from Mr. E. C. Andrews returning thanks for congratulations on the invitation extended to him to deliver the Silliman Lectures at Yale during 1927.

The President announced that the Council had decided to perpetuate the memory of the late Mr. J. J. Fletcher by the institution of a "J. J. Fletcher Memorial Lecture" which would be delivered annually in Sydney at the invitation of the Council, the subject of the lecture being restricted to some branch of Natural History. In addition it is proposed to erect a suitable Memorial Tablet in the Society's Hall or other place determined by the Council, and members are given the opportunity of subscribing towards the cost of this tablet.

The Donations and Exchanges received since the previous Monthly Meeting (30th June, 1926) amounting to 21 Vols., 87 Parts or Nos., 15 Bulletins, 5 Reports and 1 Pamphlet, received from 67 Societies and Institutions were laid upon the table.

PAPERS READ.

1. On a Small Collection of Plants from the Rigo District, Papua. By C. T. White, F.L.S.

2. The Trichoceridae (Diptera) of Australia. By C. P. Alexander. (*Communicated by Dr. E. W. Ferguson.*)

3. Notes on the Native Flora of New South Wales. Part xi. Moree to Mungindi and Moonie R., with a Description of a New Species of *Eucalyptus*. By R. H. Cambage, C.B.E., F.L.S.

4. Gasteromycetes of Australasia. v. The Genus *Calvatia*. By G. H. Cunningham.

5. Stratigraphical and Structural Geology of the Carboniferous Rocks in the Mt. Mirannie and Mt. Dyrring Districts, near Singleton, N.S.W. By G. D. Osborne, B.Sc.

NOTES AND EXHIBITS.

Mr. H. J. Carter exhibited calcareous insect puparia from the South Australian Coast, sent by Mr. A. M. Lea, probably of *Leptops duponti*, a large and very common weevil, some of these insects being actually found in such cases. Mr. Lea has published a note on them (*Rec. S. Aust. Mus.*, 1926).

Mr. W. W. Froggatt exhibited a very fine series of male and female galls of the gall-making Coccid (*Apiomorpha excupula* Fuller) on Eucalyptus foliage from near Gosford, N.S.W. The male galls in this species are neither on the leaves nor on the female galls, as is usually the case, but spring out round the base of the female galls on the branchlets.

Mr. David G. Stead contributed the following note:—

"A few days since, while standing on the shore of Watson's Bay, Port Jackson, my attention was attracted to an extraordinary movement taking place in the water close to a rock, where the depth was about six feet. The water was seen to "boil" twice in the manner seen when a body moves just below the surface. Then a third time, the "boil" occurred and a Crested Tern was observed for an instant a few inches below the surface. Then all movement ceased. Next day the wing of a Tern broken off at the proximal end of the humerus was washed up about fifty feet away from where the incident was observed. It is suggested as probable that the Tern dived after a small fish and was seized by an Octopus. The wing might readily have been broken by a violent flap against the resistance of the water".

Professor Harrison exhibited flowering branches of an apparent mutation of *Acacia Baileyana*, in which the waxy secretion which gives the "silver" appearance to the foliage of the typical plant was absent, the leaves being green. The flowers are also slightly darker in colour. Two green-leaved plants have been under observation for the past two years at Gordon, and have just flowered for the first time. One is growing on a piece of vacant land, which was cleared two years ago, and upon which more than a hundred typical *A. Baileyana* have made their appearance, the progeny of a number of trees which were cut down. This individual is growing in a group of half a dozen plants, and cannot be distinguished from them in habit, but its foliage difference is very obvious. A second green plant growing on this land has proved to be *A. decurrens*, which grows in the neighbourhood. Hybridisation appears to be out of question, since the species do not flower at the same time. The second mutant is growing on a footpath, and has probably been derived from one of two normal trees of *A. Baileyana* on the opposite side of the road. The branches exhibited are from this individual. Dr. Hall (These PROCEEDINGS, xxxv, 1910, 426) exhibited similar specimens as hybrids, and mentioned their occurrence in proportions as large as 20% in nursery cultures.

Mr. T. C. Roughley exhibited a series of 110 drawings of marine organisms found in the plankton and the food of oysters in the Hawkesbury River from April to June, 1925. These embraced Diatoms, Flagellates, Dinoflagellates and Infusoria. The commonest genera of Diatoms found were *Coscinodiscus*, *Bacillaria*, *Pleurosigma*, *Navicula*, *Chaetoceras*, *Rhizosolenia*, *Melosira*, *Thallassiothrix*,

Surirella, *Biddulphia*, *Asterionella* and *Pinnularia*. The Dinoflagellates embraced a number of species of *Ceratium*, *Peridinium* and *Dinophysis*. The most abundant organism found during the period of the investigation was the Diatom *Coscinodiscus*, of which several species were recorded. At times in Cowan Creek a large species of this Diatom was so abundant that the meshes of the plankton net clogged up after being towed for a few minutes. Mr. Roughley lamented the fact that the Australian marine plankton is practically an unworked field; owing to the economic relation of the marine plankton to the fisheries, including oysters and crustacea, it is a great pity that the subject has not received the specialized study which its importance warrants.

ORDINARY MONTHLY MEETING.

25th August, 1926.

Mr. W. W. Froggatt, F.L.S., in the Chair.

A letter was received from Professor J. T. Wilson returning thanks for congratulations on his receiving the Hon. LL.D. of the University of Edinburgh.

The Chairman offered congratulations to Dr. P. D. F. Murray on having obtained his Doctorate of Science in the University of Sydney.

The Donations and Exchanges received since the previous Monthly Meeting (28th July, 1926) amounting to 19 Vols., 113 Parts or Nos., 18 Bulletins, 6 Reports and 6 Pamphlets, received from 75 Societies and Institutions and 5 private donors were laid upon the table.

PAPERS READ.

1. A Revision of certain Australian Chenopodiaceae. By R. H. Anderson, B.Sc. (Agr.).
2. Notes on *Melaleuca pubescens* Schauer and *M. Preissiana* Schauer. By E. Cheel.
3. Description of a New Species of *Diuris* from Barrington Tops, N.S.W. By Rev. H. M. R. Rupp. (*Communicated by Mr. E. Cheel.*)
4. On some Australian Curculionidae. By A. M. Lea, F.E.S.

NOTES AND EXHIBITS.

Mr. David G. Stead drew the attention of members to the extraordinary ocean phenomenon observed by the master of the steamer "Maheno" on the 23rd instant in latitude 33° 45′ S., longitude 156° 06′ E. A large disturbed area was passed over, with the water welling up and swirling as though it were under the influence of a submarine disturbance. The affected area was estimated to be about 1½ mile in diameter. According to one witness it had the appearance of a "big tide rip". Many sharks and sea birds were seen in the vicinity and a considerable amount of seaweed was floating. Temperature observations gave a normal temperature of 65° F. Mr. Stead stated that he had ascertained from the Rev. Dr. Pigot, of Riverview College, that there had been no earth disturbance in the vicinity, and suggested that the phenomenon was solely due to the effect of the great south-flowing current striking a stationary body of water, or one flowing in the opposite direction, possibly aided also by the effect of local eddies formed by the wide ocean stream pouring off the submarine plateau (to the north), and into the deeper water of the Tasman Sea.

Mr. W. L. Wearne exhibited a specimen showing the development in *Cedrela Toona* Roxb. (Cedar) of the larvae and pupae of the Powder Post Borer (*Lyctus*

sp.). The moisture content of the wood was in one case 46·9% and the other 44·9% on the dry weight. This proves definitely that infection can occur in unseasoned wood, contrary to the usually accepted belief. The surface of the log had not been broken.

Mr. W. W. Froggatt exhibited a section of White Cypress pine wood (*Callitris calcarata*) sent by Mr. W. H. Hadley, Forest Office, Condobolin, showing damage to sound timber caused by a colony of Wood Ants (*Podomyrma bimaculata* Forel). The nest was cut out of the solid wood entered through a knot hole in the bark 20 feet from the ground. It measured nearly two feet in length. In the keyhole-like opening were six immature female coccids firmly attached to the surface of the wood and all the ants of the community, about two hundred, had to walk over these coccids every time they went through the opening. The coccids were *Lecanium callitris*, recently described in the PROCEEDINGS.

ORDINARY MONTHLY MEETING.

29th SEPTEMBER, 1926.

Dr. E. W. Ferguson, President, in the Chair.

The President referred to the death of Mr. Charles Hedley, who had been a Member of the Society since 1891, President 1909-1911, and Member of Council 1897-1924. A letter had been received from Mrs. Hedley returning thanks for the sympathy of members of the Society.

The President announced that Professor A. N. Burkitt had been elected a member of Council to fill the vacancy caused by the resignation of Professor H. G. Chapman.

The President offered congratulations to Mr. A. F. Basset Hull on his election as a Corresponding Member of the Academy of Natural Sciences of Philadelphia.

The President announced that the Council is prepared to receive applications for four Linnean Macleay Fellowships tenable for one year from 1st March, 1927, from qualified candidates. Applications should be lodged with the Secretary, who will afford all necessary information to intending candidates, not later than Wednesday, 3rd November, 1926.

The Donations and Exchanges received since the previous Monthly Meeting (25th August, 1926) amounting to 13 Vols., 75 Parts or Nos., 12 Bulletins and 3 Reports, received from 60 Societies and Institutions and 2 private donors were laid upon the table.

PAPERS READ.

1. Revision of Australian Lepidoptera: Drepanidae, Limacodidae, Zygaenidae. By A. J. Turner, M.D., F.E.S.

2. Revision of *Athemistus* and *Microtragus* (Cerambycidae) with Notes, and Descriptions of other Australian Coleoptera. By H. J. Carter, B.A., F.E.S.

3. An Investigation of the Cause of an Oyster Mortality on the George's River, New South Wales, 1924-5. By T. C. Roughley.

NOTES AND EXHIBITS.

Mr. H. J. Carter exhibited a series of Buprestidae, collected during August-September, 1926, in Western Australia, representing four genera and fifteen species. *Stigmodera gratiosa* was amongst the species collected and Mr. Carter also exhibited a necklace, belonging to Mrs. Carter, consisting of a number of these beetles suitably mounted.

Mr. W. W. Froggatt exhibited a sample of red cedar, cut from a felled tree on the Ellenborough River on the Bulga, containing pin-hole borers (*Platypus omnivorus*); and also specimens of the mounted beetles. He also exhibited fifty specimens of the gall-making weevil (*Strongylorrhinus ochraceus*) bred from a single gall on a coppice iron-bark in the State Forest near Clarencetown.

Professor L. Harrison exhibited three species of frogs collected in south-western Australia during the recent visit of delegates to the A.A.A.S. Congress. *Crinia leai* Fletcher, known only from Mr. Fletcher's original series, was found numerous at Bridgetown. A new species of *Pseudophryne* and a second new species apparently related to *Crinia leai* collected under logs in the Karri country at Pemberton were also shown. It is remarkable that two such distinct forms should have been discovered during a visit lasting less than three hours, and it appears that the fauna of this part of Western Australia is still very imperfectly known.

Mr. G. P. Whitley exhibited some live specimens of the elvers of the Freshwater Eel (*Anguilla australis*). Mr. F. A. McNeill had brought one to the Australian Museum from Long Bay that morning (29th September), so Dr. C. Anderson and Mr. Whitley visited the locality in the hope that an "Eel-fare" might occur. Specimens were far from plentiful, however, but thirty-one elvers, some of which were slightly pigmented, were found under stones and in inconspicuous places at the bottom of a rivulet that flowed across Long Bay beach into the sea. One was actually in salt water, but the majority were some yards upstream. Their lengths varied from 47-75 mm., with an average of about 57 mm. The Jollytail or Eel-Gudgeon (*Galaxias attenuatus*) was very common in the same stream, and, in the neighbourhood of Sydney, evidently migrates from the sea at about the same time each year as the eels.

Dr. E. W. Ferguson exhibited a collection of Bombyliidae taken in Western Australia during the A.A.A.S. meeting. The genus *Comptosia* was most strongly represented both in species and numbers, but species of *Bombylius*, *Sisyromyia*, *Systoechus*, *Dischistus*, *Acreotrichus*, *Systropus*, *Anthrax* and *Docidomyia* were also taken.

ORDINARY MONTHLY MEETING.

27th October, 1926.

Dr. E. W. Ferguson, President, in the Chair.

Candidates for Linnean Macleay Fellowships, 1927-28, were reminded that Wednesday, 3rd November, 1926, is the last day for receiving applications.

The Donations and Exchanges received since the previous Monthly Meeting (29th September, 1926) amounting to 5 Vols., 78 Parts or Nos., 4 Bulletins, 2 Reports and 14 Pamphlets, received from 49 Societies and Institutions and 3 private donors were laid upon the table.

PAPERS READ.

1. Notes on Australian Diptera. No. ix. By J. R. Malloch. (*Communicated by Dr. E. W. Ferguson.*)

2. On some Land Planarians from Barrington Tops, N.S.W., with Descriptions of New Species. By Lucy M. Wood, B.A.

3. Revision of Australian Syrphidae (Diptera). Part ii. Subfamily Milesiinae. By E. W. Ferguson, M.B., Ch.M., D.P.H.

NOTES AND EXHIBITS.

Mr. A. H. S. Lucas exhibited (1) a luxuriant species of *Champia* probably new: its nearest ally is *C. tasmanica*, (2) specimens of *Caulerpa ligula* Harv., a South African species not hitherto recorded from Australia. The specimens were from Botany Bay and Balmoral, those from the latter locality possessing fronds a foot or more long.

Mr. W. W. Froggatt exhibited (i) damaged tips of red cedar (*Cedrela australis* F.v.M.) from Iron Pot Creek Brush, near Kyogle, showing infestation by the Cedar Tip Moth (*Hypsolopha robusta* Moore). The larvae were just starting upon the small seedlings up to seven or eight feet in height, and appear to damage those growing in the open more than those in the shelter of the forest; (ii) live specimens of a small Buprestid beetle (*Anthaxia* sp.) cut out of a fallen brush timber tree at Iron Pot Creek, near Kyogle. Larvae, pupae and perfect beetles were all taken in the wood; (iii) the life history of a Dipteron (Family Therevidae) from Bulga Plateau. The slender white worm-like larva is found under stones in comparatively dry places; one pupated early in October and the fly emerged about ten days later.

Mr. E. Le G. Troughton exhibited (by permission of the Director of the Australian Museum) the skull of a very large bandicoot with a basal length of 82 mm., from the Clarence River, New South Wales, which has been identified as *Isoodon macrourus* Gould. The specimen has been in the old collection of the Museum for many years and is identical with the skull incorrectly listed as *Perameles nasuta* by Krefft in 1864 (Cat. Mamm. in Aust. Mus.), presented by Mr. James F. Wilcox. Gould described *macrourus* from Port Essington, Northern Territory, and it has since been recorded from various localities in north-east Queensland, including the Endeavour River, near Cooktown, where a specimen was collected by the Chevert Expedition; this specimen was described by Ramsay as variety *torosus*, now considered doubtfully distinct, and is preserved in the Macleay Museum. Collett has recorded *macrourus* as far south as Rockhampton, so that the present extension provides a remarkable range for this bandicoot, the cranial characters of a Port Darwin specimen intergrading so as to leave little doubt that the present example is correctly identified.

The President announced that Mrs. Fletcher had presented to the Society the desk given to the late Mr. J. J. Fletcher by members on the occasion of his retirement from the Secretaryship of the Society.

The President also, on behalf of members, wished Dr. Walkom *bon voyage* and a successful year's work at Cambridge University.

ORDINARY MONTHLY MEETING.

24th November, 1926.

Dr. E. W. Ferguson, President, in the Chair.

The President announced that the Council had reappointed Miss May M. Williams and Dr. I. M. Mackerras to Linnean Macleay Fellowships in Botany and Zoology respectively for one year from 1st March, 1927, and appointed Miss Ida Brown and Miss Hazel C. Weekes to Fellowships in Geology and Zoology for one year from the same date.

The Donations and Exchanges received since the previous Monthly Meeting (27th October, 1926) amounting to 16 Vols., 174 Parts or Nos., 1 Bulletin, 4 Reports and 1 Pamphlet, received from 57 Societies and Institutions and 6 private donors were laid upon the table.

PAPERS READ.

1. The Physiography and Geography of the Hawkesbury River between Windsor and Wiseman's Ferry. By Miss Lesley D. Hall, B.Sc.

2. A Reclassification of the Australian Robberflies of the *Cerdistus-Neoitamus* Complex (Diptera-Asilidae). By G. H. Hardy.

3. Notes on Australian Marine Algae. iii. The Australian Species of the Genus *Nitophyllum*. By A. H. S. Lucas, M.A., B.Sc.

4. Analyses of three Australian Rocks. By M. Aurousseau, B.Sc.

5. Gasteromycetes of Australasia. vi. The Genus *Lycoperdon*. By G. H. Cunningham.

NOTES AND EXHIBITS.

Mr. A. H. S. Lucas exhibited specimens of species of *Nitophyllum* in illustration of his paper.

Dr. I. M. Mackerras exhibited specimens of a larval Nematode, *Agamomermis* sp., parasitic on the body cavity of larvae of *Anopheles annulipes* Walk. taken at Eidsvold, S. Queensland in October, 1926.

Mr. G. M. Goldfinch exhibited a female specimen of *Troides euphorion* taken recently by him in the Cairns district. Apparently at an early stage in the pupal development an injury had been sustained, the right hindwing showing most interesting modifications in repairing the damage. In the process of repair three separate and distinct processes have occurred: (1) A modification of the venation, involving construction of a branch from the lower margin of the cell from which spring veins 2 and 3 and an entirely new vein; (2) a modification of the crenulations in the termen, providing an additional projection at the termination of the new vein; (3) the preservation of the general scheme of colour markings by the formation of an additional white, black-centred spot between the veins. It was pointed out that this new spot is not the cleavage of a simple white spot by a vein, but is the development of a complete spot, i.e. a white spot with a black centre. The insect was capable of perfect flight and prior to capture no peculiarity was noticed.

Mr. H. J. Carter drew attention to an error on his part. By a lapse of memory he had used the name *Nyctozoilus macleayi* for two different species in the Macleay Museum collection: (*a*) These PROCEEDINGS, 1926, p. 68, for a unique specimen from Coonabarabran; (*b*) These PROCEEDINGS, 1926, p. 511, for specimens from Monaro. He now considered that the latter is too near *N. reticulatus* Bates to deserve specific distinction and should be placed as a synonym of that species.

DONATIONS AND EXCHANGES.

Received during the period 26th November, 1925, to 24th November, 1926.

(*From the respective Societies, etc., unless otherwise mentioned.*)

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Welsh Plant Breeding Station, University College of Wales.—Advisory Bulletin No. 1 (1925): "The Effect of Length of Day upon the Growth and Reproduction of some Economic Plants," by M. A. H. Tincker (Reprint from Annals of Botany, xxxix, No. 156, 1925); "The Welsh Journal of Agriculture", Vol. ii (1926).

ACCRA.

Geological Survey of the Gold Coast.—Bulletin No. 1 (1925); Reports for the Periods April, 1923-March, 1924 (1925); April, 1924-March, 1925 (no date).

ADELAIDE.

Australasian Antarctic Expedition, 1911-1914, see under Sydney.

Department of Mines: Geological Survey of South Australia.—Annual Report of the Director of Mines and Government Geologist for 1925 (1926); Bulletin No. 12 (1926); Mining Review for the Half Years ended June 30, 1925 (No. 42), (1925); December 31, 1925 (No. 43), (1926).

Field Naturalists' Section of the Royal Society of South Australia.—"The South Australian Naturalist," vii, 1-3 (1925-1926).

Public Library, Museum and Art Gallery of South Australia.—Forty-second Annual Report of the Board of Governors for 1925-1926; Records of the South Australian Museum, iii, 2 (1926).

Royal Geographical Society of Australasia, South Australian Branch.—Proceedings, xxvi, Session 1924-25 (1926).

Royal Society of South Australia.—Transactions and Proceedings, xlix (1925).

South Australian Ornithological Association.—"The South Australian Ornithologist", viii, 5-8 (1926).

University of Adelaide.—"The Australian Journal of Experimental Biology and Medical Science", ii, 4 (T.p. & c.) (1925); iii, 1-3 (1926).

Woods and Forests Department.—Annual Progress Report for the Year 1924-25 (1925).

ALBANY.

New York State Library, University of the State of New York.—New York State Museum Bulletin, Nos. 249/250 (1923)-254 (1924); 256-263; 265-266 (1925); 268 (1926); New York State Museum Report, li, Vol. ii (1897); lii, Vol. i (1898); lvi, Vol. iii (1902); lix, Vol. i (1905).

ALGER.

Institut Pasteur d'Algérie.—Archives, iii, 1-4 (T.p. & c.) (1925).

Société d'Histoire Naturelle de l'Afrique du Nord.—Bulletin, xvi, 1925, 8 (1925); xvii, 1926, 1-6 (1926); Tables Recapitulatives, T. i-xii, 1909-1921 (no date).

AMSTERDAM.

Nederlandsche Entomologische Vereeniging.—Entomologische Berichten, vi, 144 (1925); vii, 145-149 (1925-1926); Tijdschrift voor Entomologie, lxviii, 1925 (1925); lxix, 1-2 (1926).

Royal Academy of Sciences.—Jaarboek, 1918, 1919 (1919, 1920); 1921-1922, 1923-1924, 1924-1925 (1923-1925); Proceedings of the Section of Sciences, xxi, 1-2 (T.p. & c.) (1919); xxv-xxvii (1923-1924); Verhandelingen, 2nd Section, xvi, 6 (T.p. & c.) (1919); xx, 5-6 (T.p. & c.) (1919-1920); xxii, 5 (T.p. & c.) (1922); xxiii, 1-5 (T.p. & c.) (1923-1924); xxiv, 1-2 (1925); Verslagen Afdeeling Natuurkunde, xxvii, 1-2 (T.p. & c.) (1919); xxxi-xxxiii (1923-1924).

ANN ARBOR.

University of Michigan.—Contributions from the Museum of Geology, ii, 4-6 (1925); Occasional Papers of the Museum of Zoology, T.p. & c. for Nos. 129-152 (Vol. vi, 1923-1924); 153-165 (1924-1925); Papers of the Michigan Academy of Science, Arts and Letters, v, 1925 (1926).

AUCKLAND.

Auckland Institute and Museum.—Annual Report, 1925-26 (1926).

BALTIMORE.

Johns Hopkins University.—University Circulars, N.S. 1924, 7 (1924); 1925, 1-10 (1925); 1926, 1 (1926).

BANDOENG.

Geological Survey in the Netherlands East Indies.—Vulkanologische Mededeelingen, Nos. 7-8 (1926, 1925); Wetenschappelijke Mededeelingen Nos. 3-4 (1925-1926).

BARCELONA.

Real Academia de Ciencias y Artes de Barcelona.—Boletin, v, 3 (1926); Memorias, xix, 8-14 (1925-1926); Nomina del Personal Academico, 1925-1926 (1926).

BASEL.

Naturforschende Gesellschaft.—Verhandlungen, xxxi, 1919-20 (1920); xxxvi, 1924-25 (1925).

BERGEN.

Bergens Museum.—Aarbok, 1924-25, 1-2 (T.p. & c.) (1925-1926); Aarsberetning, 1924-25 (1925); Register til Bergens Museums Aarbok, 1883-1925 (1926).

BERKELEY.

University of California.—Publications: Botany, x, 1 (1922); T.p. & c. (1922-1924); xii, 4-8 (1926); xiii, 5-10 (1926); Entomology, iii, 5 (T.p. & c.) (1926); iv, 1 (1926); Geology, xvi, 1-4 (1926); Physiology, v, 16-19 (1926); vi, pp. 1-216 (complete) (1926); Zoology, xxi, 14-18 (1926); xxiv, 4 (1926); T.p. & c. for xxvi (1923-1925); xxviii, 1-23 (T.p. & c.) (1925-1926); xxix, 1-7 (1926); xxx, 1-5 (1926).

BERLIN.

Botanischer Garten und Museum.—Notizblatt, ix, 86-88 (1925-1926).

Deutsche Entomologische Gesellschaft, E.V.—Deutsche Entomologische Zeitschrift, 1925, 4-5 (T.p. & c.) (1925-1926); 1926, 1-2 (1926).

Deutsche Entomologische Museum.—Entomologische Mitteilungen, xv, 1-4 (1926); Supplementa Entomologica, Nos. 12-13 (1926).

Notgemeinschaft der Deutschen Wissenschaft.—"Flora", Neue Folge, xviii and xix (Festschrift zum Siebzigsten Geburtstage von Karl von Goebel in München) (1925); xx, 1-4 (T.p. & c.) (1925-1926); xxi, 1 (1926).

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Naturforschende Gesellschaft.—Mitteilungen a.d. Jahre 1925 (1926); Verhandlungen, 1925 (1925).

BIRMINGHAM.

Birmingham Natural History and Philosophical Society.—List of Members, 1926, and Annual Report, 1925; Proceedings, xv, 5, Session 1925-26 (1926).

BOMBAY.

Bombay Bacteriological Laboratory.—Report for the Year 1924 (1925).

Bombay Natural History Society.—Journal, xxx, 4 (T.p. and Index to Parts 1-2 and Parts 3-4) (1925-1926); xxxi, 1-2 (1926).

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Naturhistorische Verein der Preussische Rheinlande und Westfalens.—Sitzungsberichte, 1913, 2 (T.p. & c.) (1914); 1914 (1916); 1916 (for 1915 and 1916) (1918); 1919 (for 1917-1919) (1920); 1922 (for 1920-1922) (1923); 1923 (1925); 1924 (1925); Verhandlungen, 70, 1913, 2 (T.p. & c.) (1914)-82, 1925 (1926).

BOSTON.

American Academy of Arts and Sciences.—Proceedings, lx, 1-14 (T.p. & c.) (1925); lxi, 1-6 (1925-1926).

Boston Society of Natural History.—Proceedings, xxxvii, 2-4 (T.p. & c.) (1923-1924); xxxviii, 1-3 (1925).

BRESCIA.

"*La Nuova Notarisia*", Serie xxxvi, 1925 (1925). (*From the Publisher, Hon. Famille De Toni.*)

BRISBANE.

Department of Agriculture and Stock.—Queensland Agricultural Journal, T.p. & c. for Vol. xxiii; xxiv, 6 (T.p. & c.) (1925); xxv, 1-6 (T.p. & c.) (1926); xxvi, 1-4 (1926).

Department of Mines, Queensland Geological Survey.—Publication No. 277 (1926).

"*Queensland Government Mining Journal*" (*from the Editor*).—xxvi, Nov.-Dec., 1925 (T.p. & c.) (1925); xxvii, Jan.-Nov., 1926 (1926).

Queensland Museum.—Memoirs, viii, 3 (T.p. & c.) (1926).

Queensland Naturalists' Club and Nature-Lovers' League.—"The Queensland Naturalist", v, 3-6 (1925-1926).

Royal Society of Queensland.—Proceedings, xxxvii, 1925 (1926).

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Botanical Society of America.—American Journal of Botany, xi, 10 (T.p. & c.) (1924); xii, 9-10 (T.p. & c.) (1925); xiii, 1-7 (1926).

Brooklyn Institute of Arts and Sciences: Brooklyn Museum.—Science Bulletin, iii, 3-4 (1925).

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Académie Royale de Belgique.—Annuaire, 86th Année, 1920 (1920); 92nd Année, 1926 (1926); Bulletin de la Classe des Sciences, 1925, 4-12 (T.p. & c.) (1925); 1926, 1-2 (1926).

Société Entomologique de Belgique.—Annales, lix-lxiv (1919-1924); Bulletin, i-vi (1919-1924); Bulletin and Annales, lxv, 1-7, 9-12 (Index) (1925-1926); lxvi, 1-7 (1926); Mémoires, xxii (1913-1914).

Société Royale de Botanique de Belgique.—Bulletin, lvii, 2 (T.p. & c.) (1925).

Société Royale Zoologique de Belgique.—Annales, xlvi, 1911 (1911-1912); lv, 1924 (1925).

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Musée National Hongrois.—Annales, xxi, 1924 (1924).

CAEN.

Société Linnéenne de Normandie.—Bulletin, 7th Série, vii, 1924 (1925).

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Geological Survey of India.—Memoirs, xlvi, 2 (T.p. & c.) (1926); l, 1 (1925); li, 1 (1926); lii, 1 (1925); Memoirs, Palaeontologia Indica, N.S. T. p. & c. for Vol. iii; viii, 4 (T.p. & c.) (1926); Records, lvi, 4 (T.p. & c.) (1925); lvii (1925); lviii, 2-4 (T.p. & c.) (1925-1926); lix, 1-2 (1926); "A Bibliography of Indian Geology, Part iv. Palaeontological Index" (1926).

Indian Museum.—Records, xxvii, 5-6, Appendix (T.p. & c.) (1925-1926); xxviii, 1-2 (1926).

CAMBRIDGE, England.

Cambridge Philosophical Society.—Transactions, xxiii, 8-9 (1925-1926).

CAMBRIDGE, Mass.

Museum of Comparative Zoology at Harvard College.—Annual Report of the Director for 1924-1925 (1925); Bulletin, iii, 5; v, 2-3 (1878); lvii, 8 (T.p. & c.) (1925); lxi, 1, 3 (1917); lxvii, 2-11 (1925-1926).

CAPE TOWN.

Royal Society of South Africa.—Transactions, xiii, 1-3 (1925-1926).

South African Museum.—Annual Report for the Year ended 31st December, 1925 (1926); Annals, xx, 5-6 (T.p. & c.) (1925-1926); xxii, 1 (1925); xxiii, 1-2 (1925-1926).

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Field Museum of Natural History.—Publications, Botanical Series, iv, 3-4 (1925); Museum Technique Series, No. 1 (1925); Ornithological Series, i, 8-11 (T.p. & c.) (1907-1917); Report Series, Title page for Vol. i; Title page and Index to Illustrations for Vols. ii-v; vi, 4-5 (1925-1926); Zoological Series, Title page for Vol. ix; xii, 8-11; xiii, 4; xiv, 3; xv, 2 (1925).

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Canterbury Museum.—Records, ii, 5 (T.p. & c.); iii, 1 (1925-1926).

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CLUJ, Roumania.

Gradina Botanica.—Bulletin, v, 3-4, Appendix 1-2 (T.p. & c.) (1925).

COLD SPRING HARBOR.

Station for Experimental Evolution, Carnegie Institution of Washington.—Annual Report of the Director of the Department of Genetics, 1924-1925 (Extracted from Year Book No. 24 for the Year 1925) (1925).

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Colombo Museum.—Spolia Żeylanica, T.p. & c. for Vol. xii (1924); Spolia Zeylanica (Ceylon Journal of Science, Section B—Zoology and Geology), xiii, 3 (1926).

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American Chemical Society.—Industrial and Engineering Chemistry, xvii, 11-12 (T.p. & c.) (1925); xviii, 1-9 (1926); News Edition, iii, 19-24 (Index) (1925); iv, 1-19 (1926).

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Ohio State University.—Bulletin, xxx, 11 (T.p. & c. for Vol. ii, Bulletins v-x, Ohio Biological Survey, 1916-1921) (Jan., 1926).

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Det. Kgl. Danske Videnskabernes Selskab.—Biologiske Meddelelser, iv, 5-6 (T.p. & c.); v, 1-7 (1925-1926); Oversigt, Juni, 1924-Maj, 1925 (1925).

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Royal Irish Academy.—Proceedings, Section B, xxxvii, Nos. 9, 14, 15 (1925-1926).

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Durban Museum.—Museum Reports for the Municipal Years ended 31st July, 1924 and 1925 (1925-1926).

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Michigan Agricultural College, Agricultural Experiment Station.—Report of the Veterinary Division for the Year ending June 30, 1924; "The Nature of *Bacterium Abortus* Infection in the Udder of the Bovine", by R. A. Runnells and I. F. Huddleson (Reprinted from "The Cornell Veterinarian", October, 1925).

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Royal Society of Edinburgh.—Proceedings, xlv, 4 (T.p. & c.), Session 1924-25; xlvi, 1-2, Session 1925-26; Transactions, liv, 2, Session 1925-26 (1926).

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FREIBURG, I. BR.

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GENEVA.

Société de Physique et d'Histoire Naturelle.—Compte Rendu des Séances, xlii, 2-3 (T.p. & c.) (1925); xliii, 1-2; Memoires, xl, 2 (1926).

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New York Agricultural Experiment Station.—Annual Report, 33rd, Part 2, 1925, "The Small Fruits of New York", by U. P. Hedrick (1925).

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Denison University.—Journal of the Scientific Laboratories, xxi, pp. 1-283 (1925).

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Societas Scientiarum Fennica.—Arsbok-Vuosikirja, iii, 1924-1925 (1925); Bidrag, 80, 4-5 (1925); Commentationes Biologicae, ii, 1-3 (1925); Ofversigt, lvii, A, 1914-1915 (1915); lviii, C, 1915-1916 (1916).

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Tasmanian Field Naturalists' Club.—Easter Camp, 1926 (1926); "The Tasmanian Naturalist", N.S. i, 3-5 (1925-1926); ii, 1 (1926).

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Bernice Pauahi Bishop Museum.—Bulletins 15-28 (1924-1926); Memoirs, v, 3 (T.p. & c.) (1919); Occasional Papers, T.p. & c. for Vol. iii (1907-1917).

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Indiana Academy of Science.—Proceedings, 33-34, 1923-1924 (1924-1925).

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Cornell University.—Eighty-nine separates (1922-1926).

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South African Association for the Advancement of Science.—South African Journal of Science, xxii (1925).

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Ohara Institute for Agricultural Research.—Berichte, ii, 5 (T.p. & c.); iii, 1 (1925-1926).

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Scripps Institution for Biological Research of the University of California.—"Statistical Studies of Surface Catches of Marine Diatoms and Dinoflagellates made by the Yacht "Ohio" in Tropical Waters in 1924", by W. E. Allen (Trans. Amer. Micro. Soc. Jan., 1925).

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North, D. S., Richmond River, N.S.W.—"Leaf-scald: A Bacterial Disease of Sugar Cane" (Sydney, 1926).

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Tadgell, A. J., Melbourne (donor).—"The Victorian Naturalist", Vol. xliii, No. 2 (1926).

Tillyard, R. J., M.A., D.Sc., F.R.S., Nelson, New Zealand (donor).—Thirteen Separates: "The Genus Pachyrhamma (Rhaphidophorinae; Orthoptera)", by D. D. Milligan (*Trans. N.Z. Inst.* 56, p. 422, 1926); By R. J. Tillyard: "Kansas Permian Insects". Parts 5-9 (*Amer. Journ. Sci.* x, July, 1925; xi, Jan., Feb., Apr., May, 1926); "Caddis-flies (Order Trichoptera) from the Chatham Islands" (*Rec. Cant. Mus.* ii, pp. 277-284, Nov., 1925); "History of the Introduction of Beneficial Insects into New Zealand" (*Proc. Pan-Pacific Sci. Congress* (*Aust.*) (1923); "Fossil Insects in Relation to Living Forms" ("*Nature*", June 12, 1926); "A General Textbook on Entomology" (Review) (*N.Z. Journ. Sci. and Tech.* viii, 2, pp. 126-28, 1926); "A New Fossil Insect Wing from Triassic Beds near Dee Why, N.S.W."; "Two New Species of Silky Lacewings (Family Psychopsidae, Order Neuroptera Planipennia) from Australia"; "Upper Permian Insects of N.S.W. Pt. 1" (From *Proc. Linn. Soc. N.S.W.* l, pt. 4, 1925, and li, 2, 1926).

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UPPER PERMIAN INSECTS OF NEW SOUTH WALES.

PART I. INTRODUCTION AND THE ORDER HEMIPTERA.

By R. J. TILLYARD, M.A., Sc.D. (Cantab.), D.Sc. (Sydney), F.R.S., F.N.Z. Inst., F.L.S., F.G.S., F.E.S., C.M.Z.S., Entomologist and Chief of the Biological Department, Cawthron Institute, Nelson, N.Z.

(Plate i and Twenty-seven Text-figures.)

[Read 31st March, 1926.]

The honour of discovering the first Palaeozoic fossil insect wing in New South Wales belongs to Mr. John Mitchell, late Head of the Technical College, Newcastle, N.S.W. The announcement of this discovery was made in a short note communicated to these Proceedings, xxiii, 1898, p. 437. This fossil wing was unfortunately lost before it was scientifically studied; but, from Mr. Mitchell's account of it, given to me personally, I think there can be little doubt that it belonged either to the Mecoptera or the Paramecoptera. It was discovered in the shale overlying the Yard Seam at the base of the Flagstaff Hill, Newcastle, a horizon which has been calculated to lie about 800 feet vertically below the top of the Palaeozoic rocks in New South Wales (Wallarah or Bulli Coal Seam).

Mr. Mitchell has very carefully explored this horizon for many years, but has only succeeded in finding one or two further wings at or about the same horizon at Newcastle. In the meantime, however, he discovered the Belmont fossil insect beds, in a shallow quarry of hard chert about two miles from Belmont on Lake Macquarie. These beds have been worked for some years both by Mr. Mitchell and later by Mr. and Mrs. T. H. Pincombe, of New Lambton, and a large number of fossil insects have been discovered there. The Belmont horizon* is some 500 feet vertically above the previously mentioned insect-bearing strata at Newcastle, i.e. about 300 feet below the top of the Palaeozoic rocks of New South Wales.

Mr. Mitchell also discovered two wings, described by me in 1922, from burnt shale forming part of the embankment of the Burwood Colliery railway at Merewether Beach, near Newcastle. The exact horizon of these wings is doubtful, but they are either from about the same horizon as that of the original wing discovered at Newcastle, or else from the Burwood Coal Seam, a hundred feet or more vertically above that.

More recently Mr. Mitchell and Mr. Pincombe have been exploring the rocks at Warner's Bay, which are also probably about the same horizon as that of the Belmont Insects, and have succeeded in finding a fair number of insect remains, mostly in a very dark coloured chert. These fossils will be dealt with in this paper, together with a number of the later discoveries from Belmont.

* Mr. Mitchell originally estimated these beds to be some 600 feet below the top of the Palaeozoic strata, but has quite recently sent me the revised estimate here given.

The faunas disclosed by the above discoveries are all so closely similar that I propose for the present at any rate to consider them as a single whole, which I shall designate as the Upper Permian Insect Fauna of the Newcastle Coal Measures. The number of fossils now known is at any rate large enough to give us a very clear idea of this insect fauna and to enable us to draw some very interesting deductions therefrom.

The two most remarkable things about this fauna are, firstly, its high specialization, which in spite of its being an Australian fauna, is far in advance of that of any other known Palaeozoic insect fauna, and secondly, its restriction to very few Orders. The Orders represented are the Hemiptera (Suborder Homoptera only), Mecoptera, Neuroptera and Coleoptera, together with two extinct Orders not represented elsewhere, viz. the Paramecoptera and the Protocoleoptera, the former being ancestral to the Diptera, Trichoptera and Lepidoptera, the latter to the Coleoptera. The dominant Order is the Hemiptera, which, it should be noted, are also the only undoubted Hemimetabolous insects to be found in these beds; all the rest are either Holometabolous or direct ancestors of known Holometabola (Protocoleoptera) which were also, most probably, Holometabolous themselves. There are practically no large wings present, and the general average size is very small indeed. Groups usually associated with a forest flora, such as the Cockroaches (Blattoidea), or typical of a warm, subtropical climate, are entirely absent. It would, perhaps, be rash to assert positively that such typically aquatic insects as Dragonflies, Mayflies and Stoneflies did not exist there, or even that no Orthopteroid forms occurred, but the fact remains that none have so far been discovered, and the most recent consignments received from the collectors do not extend the list of Orders in any direction, though new families and genera continue to be added.

If the association of Insects represented in this fauna, with its dominance of Homoptera and Coleoptera and its abundant remains of Mecoptera, were to be presented to a specialist in fossil insects, without any evidence of its correct horizon, he would be almost bound, on the evidence, to consider it as a Triassic fauna and would probably reject straight away any suggestion that it might have come from a Palaeozoic horizon. In composition, it comes very much closer to the well-known Upper Triassic fauna of Ipswich, Queensland (though lacking many of the Orders found in these latter beds) than it does to the very large and well-known Lower Permian fauna of Kansas, where Coleoptera and Neuroptera were entirely unknown, and only four very primitive Homoptera have so far been found out of a total of about 2,000 specimens. The restricted range and high specialization of the Upper Permian fauna may be partially explained by assuming that the climate was colder than that of the Ipswich Upper Triassic; whether this was actually so or not can only be determined by a study of the associated flora.

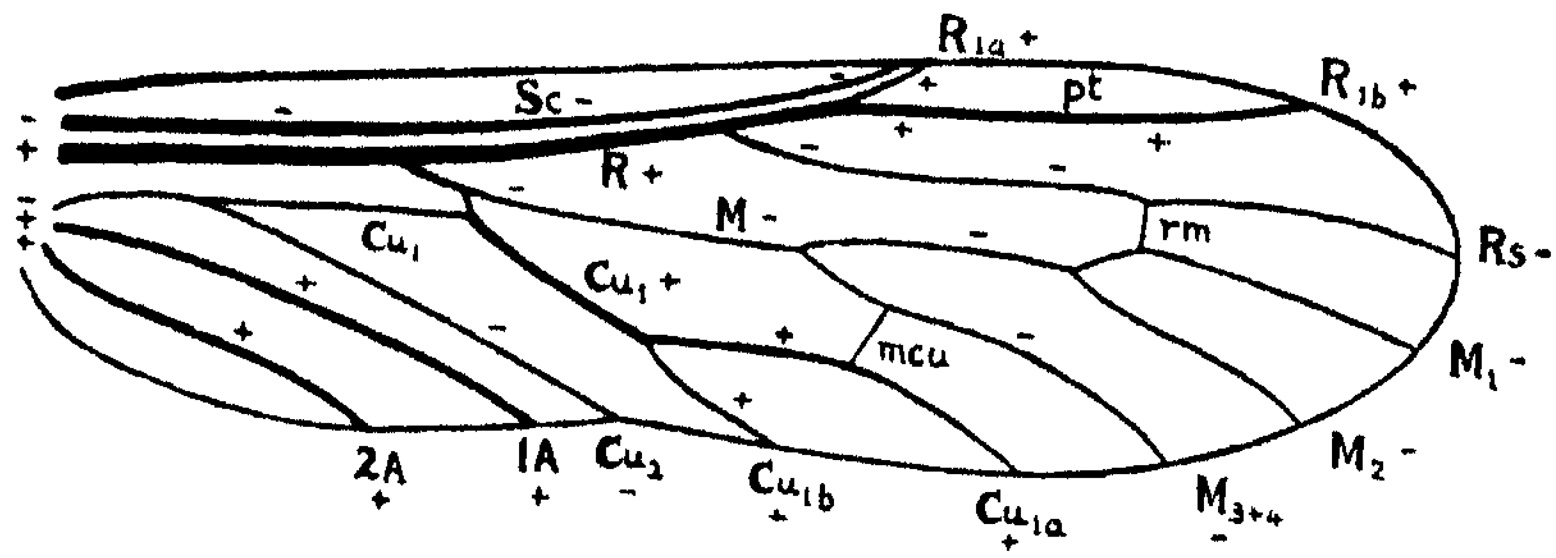
A number of fossils from these Upper Permian beds have already been described by me in scattered papers. Instead of going on with similar descriptions dealing with each collection as it comes to hand, it seems to me that it would be better to make a complete survey of the material now to hand. For this purpose, therefore, I have planned a short series of three papers, the first dealing with the Hemiptera, the second with the Mecoptera, Paramecoptera and Neuroptera, and the third with the Coleoptera and Protocoleoptera. Genera already defined and species already described from these beds will be included in the keys here given, so that each Part will offer a complete survey of the Upper Permian fauna for the Order or Orders dealt with. In the figures, the apex of the wing is always placed

to the right, to facilitate comparisons. The photographs from which Plate I has been prepared were taken by Mr. W. C. Davies, Curator of the Cawthron Institute, to whom my best thanks are due.

Order **Hemiptera.**

Suborder Homoptera.

The Hemiptera is the only Hemimetabolous Order of insects so far discovered in these beds, and is the dominant Order both as regards the number of specimens found and the number of genera and species actually represented by them. All the fossils can be definitely classed as Homoptera and have already attained a considerable degree of specialization within that Suborder. In order to understand this position, I have figured for contrast (Text-fig. 1) the tegmen of one of the four most primitive of all known Homoptera, from the Lower Permian of Kansas,



Text-fig. 1. *Permoscytina kansasensis* Till., family Permoscytinidae, Lower Permian of Kansas, U.S.A. Tegmen. 1A, 2A, the two anal veins; Cu_1, first cubitus, with its branches Cu_{1a}, Cu_{1b}; Cu_2, second cubitus or *vena dividens*, separating clavus from rest of tegmen; M, media; M_1, M_2, M_{3+4}, its three branches; *mcu*, medio-cubital cross-vein; *pt*, pterostigmatic area; R, radius; R_1, its main stem, with branches R_{1a}, R_{1b}; Rs, radial sector; *rm*, radio-median cross-vein; *Sc*, subcosta. The sign + indicates a convex, — a concave, vein.

viz. *Permoscytina kansasensis* Till. (1925). Three of the four known Lower Permian Homoptera are primitive Auchenorrhyncha of this type, having an elongated, tough tegmen with a complete but simple venation of a very definite type; the fourth is a much smaller tegmen belonging to the Sternorrhyncha, much broader and more rounded in form, with the same type of venation exactly, except that the clavus or anal area is reduced and the anal veins are absent. These primitive types resemble the primitive Copeognathous forewings from the same horizon in their general scheme of venation, particularly in the form of the pterostigmatic area (*pt*), which is an elongated area closed by R_{1a} basally and by the much longer R_{1b} posteriorly, and in the form of the first cubitus, Cu_1, which is distally forked in both Orders. In these wings, R_1 is an excessively strong, convex vein, while Rs, as in all other Palaeozoic Orders, is a concave vein. Consequently, when we find the pterostigmatic area bounded posteriorly by a strongly convex continuation of R_1, we recognize at once in this formation the homologue of the pterostigma in Mecoptera and Copeognatha, and understand that the vein marked R_{1b} is in reality the original distal portion of vein R_1, while the short piece marked R_{1a} is a branch developed to bound the pterostigmatic region basally. Comstock considered (from a study of recent Homoptera only) that the short vein R_{1a} was the true R_1, and named the vein here called R_{1b} as R_{2+3}, i.e. part of the radial

sector, in spite of the fact that it arises separately from the main stem of R. These ancient fossils undoubtedly show us the true state of the case, and an alteration of Comstock's notation in this Order is therefore necessary.

These primitive Homoptera also agree with primitive Copeognatha in the form of their clavus or anal area, which is short, bounded above by a straight *vena dividens* (Cu_2) in the form of a deep groove or concave vein, and carries two very strongly marked *convex* anal veins, 1A and 2A. The slightly excavated form of the posterior margin at the end of Cu_2 is also typical, the clavus ending distally in a sharp angle. Also it is characteristic of these wings that, when fossilized, the clavus does not separate from the rest of the wing along the *vena dividens*, but remains fully attached to it.

The simple, unbranched Rs and the three-branched M are characteristic of the most primitive members of the Homoptera, and mark them off sharply from the most primitive Copeognatha, in which Rs is forked and M four-branched. Only two cross-veins are present, viz. *rm* and *mcu*, at or near the positions shown in Text-fig. 1.

When we contrast Upper Permian and all later representatives of the Homoptera with these primitive types, we meet with a very interesting fact in the evolution of the Auchenorrhyncha. The clavus becomes lengthened, so that Cu_2 ends well beyond half-way along the posterior margin of the wing, and the *vena dividens* becomes so deeply impressed in the wing membrane that, under the usual conditions of fossilization, the tegmen splits along it, separating the clavus from the rest of the wing and giving two separate fossils. With few exceptions, we find, both in the Upper Permian and Upper Triassic beds, either the tegmen fossilized without the clavus, or else the clavus by itself. Even in the case of some of the Upper Permian Sternorrhyncha, in which the clavus is greatly narrowed and the anal veins are generally absent, we sometimes find the clavus absent and the tegmen bounded, in the fossil, by Cu_2.

Compared with the Lower Permian forms, the Upper Permian Auchenorrhynchous Homoptera show a number of other tendencies towards specialization; the subcosta is very seldom present; pterostigmatic veinlets may be developed; further distal branching of M or of Cu_1 may take place, and the main stem of Cu_1 may become very curved; the costa tends to become greatly arched and the costal space very wide. All these tendencies are again met with in the Upper Triassic fauna, but the number of highly specialized forms is considerably greater.

Nearly all the impressions found are those of tegmina or forewings, but at least one complete body has been found and two complete hindwings. The latter are of a much more primitive type than those of recent Auchenorrhyncha and possess neither a strongly developed and folded anal area nor an ambient vein.

The following is a complete list of the known genera and species of Homoptera from the Upper Permian of Australia:

Division **Auchenorrhyncha.**

Family **Scytinopteridae.**

Genus 1. PERMOJASSUS, n.g.

1. *Permojassus australis*, n. sp. Genotype. Warner's Bay.
2. *Permojassus dubius*, n. sp. Belmont.

Genus 2. ORTHOSCYTINA, n.g.

3. *Orthoscytina mitchelli*, n. sp. Genotype. Belmont.
4. *Orthoscytina quinquemedia*, n. sp. Warner's Bay.
5. *Orthoscytina indistincta*, n. sp. Belmont.
6. *Orthoscytina subcostalis*, n. sp. Belmont.

Genus 2. ORTHOSCYTINA, n.g. (*Continued*).
7. *Orthoscytina irregularis*, n. sp. Belmont.
8. *Orthoscytina belmontensis*, n. sp. Belmont.
9. *Orthoscytina obliqua*, n. sp. Belmont.
10. *Orthoscytina pincombei*, n. sp. Belmont.
11. *Orthoscytina tetraneura*, n. sp. Belmont.

Genus 3. STENOSCYTINA, n.g.
12. *Stenoscytina australiensis*. n. sp. Genotype. Belmont.

Genus 4. HOMALOSCYTINA, n.g.
13. *Homaloscytina plana*, n. sp. Genotype. Warner's Bay.

Genus 5. ELLIPTOSCARTA, n.g.
14. *Elliptoscarta ovalis*, n. sp. Genotype. Belmont.

Genus 6. ACTINOSCYTINA, n.g.
15. *Actinoscytina belmontensis*, n. sp. Genotype. Belmont.

Genus 7. PERMOSCARTA Till., 1918, p. 726.
16. *Permoscarta mitchelli* Till. Genotype. Newcastle.
17. *Permoscarta trivenulata*, n. sp. Warner's Bay.

Family **Prosbolidae.**

Genus 8. PERMOGLYPHIS, n.g.
18. *Permoglyphis belmontensis*, n. sp. Genotype. Belmont.

Genus 9. PERMODIPHTHERA, n.g.
19. *Permodiphthera robusta*, n. sp. Genotype. Belmont.
20. (?) *Permodiphthera dubia*, n. sp. Belmont.

Genus 10. MITCHELLONEURA Till., 1922*a*, p. 414.
21. *Mitchelloneura permiana* Till. Genotype. Merewether Beach.

Division **Sternorrhyncha.**

Family **Pincombeidae.**

Genus 11. PINCOMBEA Till., 1922*b*, p. 282.
22. *Pincombea mirabilis* Till. Genotype. Belmont.

Family **Permopsyllidae.**

Genus 12. PROTOPSYLLIDIUM, n.g.
23. *Protopsyllidium australe*, n. sp. Genotype. Warner's Bay.

Genus 13. PERMOPSYLLIDIUM, n.g.
24. *Permopsyllidium mitchelli*, n. sp. Genotype. Belmont.
25. *Permopsyllidium affine*. n. sp. Belmont.

Genus 14. PERMOTHEA, n.g.
26. *Permothea latipennis*, n. sp. Genotype. Warner's Bay.

Family **Lophioneuridae.**

Genus 15. LOPHIONEURA Till., 1922*a*, p. 417.
27. *Lophioneura ustulata* Till. Genotype. Merewether Beach.
28. (?) *Lophioneura conjuncta*, n. sp. Belmont.

The Upper Permian fossil Homoptera may be classified as follows:

Small to large wings (5 mm. up to 25 mm.) with a broad, well-developed clavus carrying two strong, convex anal veins .... Division AUCHENORRHYNCHA

Very small wings (less than 6 mm. long) with reduced, narrow clavus, the anal veins usually absent, rarely one or both present .... Division STERNORRHYNCHA

Division **Auchenorrhyncha.**

Most of the Upper Permian fossil tegmina in this division are closely allied to the species *Scytinoptera kokeni* Handl., from the Upper Permian of Russia. They are characterized by the strongly arched costa and wide costal space, by the unbranched Rs, by the long, straight and deeply concave Cu_2 ending far beyond half-way along the posterior margin, and by the widely separated anal veins. These are all placed in the family Scytinopteridae, which may be considered as directly ancestral to the present-day Cercopidae and Jassidae. In all of them the membrane of the tegmen shows no sign of division into a tougher basal and a softer distal portion. There are, however, three tegmina present in which such a

division is to a certain extent present, and in which the venation agrees rather with that of *Prosbole hirsuta* Handl., also from the Upper Permian of Russia, particularly in having Rs distally branched. These, together with a large hindwing evidently belonging to the same type, are here placed in a separate family Prosbolidae, which is almost certainly directly ancestral to the present-day Tropiduchidae, and also, perhaps, to other families of Fulgoroidea. Mr. F. Muir considers that these fossils are true Tropiduchidae, but the primitive character of the hindwing is probably sufficient to make it advisable to keep the two families distinct. Elsewhere (1922, p. 461) I placed the related genus *Mesodiphthera* from the Upper Trias of Ipswich within the Tropiduchidae, but further consideration of what is known of the form of the clavus and anal veins of the tegmen, and the very primitive nature of the hindwing, inclines me to keep all the Upper Permian and Upper Triassic genera in a separate family, Prosbolidae.

The following key may be used to distinguish the two fossil families:

Tegmina with Rs simple and with no transverse division into tough basal and soft distal portions .... Family *Scytinopteridae*

Tegmina with Rs branched apically and with a distinct division into tougher basal and softer distal portions .... Family *Prosbolidae*

Family Scytinopteridae.*

In classifying the Upper Permian genera of this family, it should be noted that M is always fused with R basally for some distance and then comes off from it at a point where there is a more or less marked bend in R. The bent basal vein R+M forms the anterior border of a closed *basal cell*, of which the weaker posterior border is formed firstly by Cu, then by the arching free basal portion of Cu_1; finally the cell is closed distally by a short vein connecting Cu_1 with M close to its origin (this vein almost certainly being homologous with M_5 of the Mecopteroid Orders). In leaving the basal cell, Cu_1 is sometimes a straight vein, sometimes curved markedly downwards so as to come very close to Cu_2. The manner in which R gives off Rs, and the way in which R_1 divides into R_{1a} and R_{1b}, are also valuable characters for classification. Rs is always a simple vein, but the branchings of M and Cu_1 distally vary greatly and are of use in determining genera. The following key will distinguish the tegmina of the known genera of the Australian Upper Permian:

1. The line of R is continued by Rs, R_1 being in the form of an anterior branch; a series of cross-veins present between R_1 and Rs .... Genus 7. *Permoscarta* Till.
   The line of R is continued by R_1, Rs being a posterior branch; no cross-veins between R_1 and Rs 2
2. The line of R_1 is continued by R_{1a} either as a straight line or a gentle upward curve 3
   R_{1a} not continuing the line of R_1, but placed more transversely, making a definite angle with it 5
3. Cu_1 strongly curved downwards after leaving basal cell, so as to come very close to Cu_2, then diverging from it again; pterostigmatic area long or very long 4
   Cu_1 only slightly curved after leaving basal cell; pterostigmatic area short .... Genus 1. *Permojassus*, n. g.
4. Rs arising at a point more than half-way from base of tegmen; tegmen narrow .... Genus 3. *Stenoscytina*, n. g.
   Rs arising before half-way from base of tegmen; tegmen broader .... Genus 2. *Orthoscytina*, n. g.

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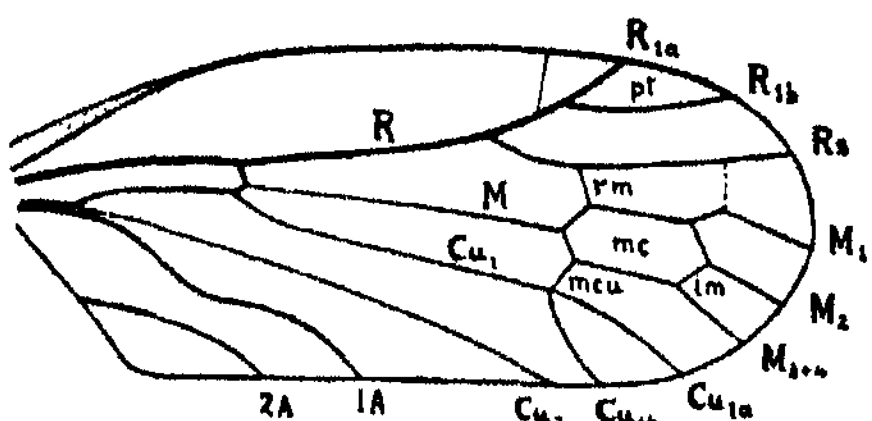
* Besides the numerous representatives of this family in the Upper Triassic of Ipswich, Q., two species have recently been discovered in the Rhaetic of South America, viz., *Wielandia* (*Tipuloidea*) *rhaetica* (Wieland) and *Tipulidites affinis* Wieland (*Amer. Journ. Sci.*, 1925, ix, p. 21); they were described by Dr. Wieland as Diptera (Tipuloidea).

5. R_{1a} and Rs arising at same point on R; distal branches of M and Cu_1 in the form of straight, slightly diverging rays .... Genus 6. ***Actinoscytina***, n. g.
Rs arising well before R_{1a}; distal branches of M and Cu_1 curved, dichotomically arranged 6
6. Tegmen of oval form, evenly rounded throughout; Cu_1 with three branches ....
.... Genus 5. ***Elliptoscarta***, n. g.
Tegmen with margin strongly curved between R_{1b} and Rs, very bluntly rounded apically; Cu_1 with only two branches .... Genus 4. ***Homaloscytina***, n. g.

Genus 1. PERMOJASSUS, n. g. (Text-figs. 2, 3.)

Tegmen.—Sc absent. R straight basally, curving gently upwards distally to end of R_{1a}. Rs short, arising well beyond half-way. R_{1b} and pterostigmatic area (*pt*) short. Basal cell long and narrow. M three-branched, with median cell (*mc*) closed by intermedian cross-vein (*im*). Cu_1 only slightly curved after leaving basal cell, two-branched. Cross-veins *rm* and *mcu* present. Clavus triangular, with marked anal angle; 1A sigmoidally curved; 2A arising about half-way down anal margin.

Hindwing.—General scheme of venation closely similar to that of tegmen, but Sc present, strongly curved, ending up about half-way along costa. M only two-branched, with *mc* and *im* absent. Cross-vein *rm* present, *mcu* absent. Anal area



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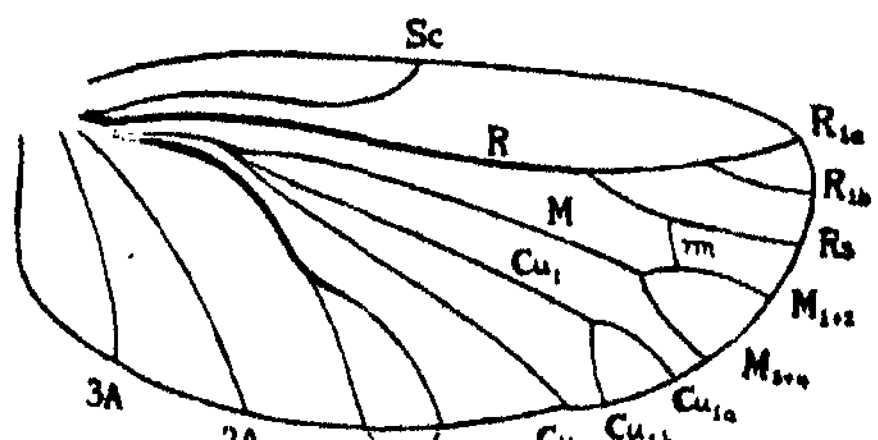

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Text-fig. 2. *Permojassus australis*, n.g. et sp., family Scytinopteridae; Upper Permian of Warner's Bay. Tegmen, with apex turned to right. Length 6 mm. Lettering as in Text-fig. 1, except *im*, intermedian cross-vein, and *mc*, closed median cell.

Text-fig. 3. *Permojassus australis*, n.g. et sp., family Scytinopteridae. Hindwing. Length 6 mm. Lettering as in Text-fig. 1.

ample but not expanding beyond the contour of the rest of the wing; 1A sigmoidally curved, but with an extra weak distal branch developed in a straight crease for folding; 2A and 3A fairly straight.

Genotype, *Permojassus australis*, n. sp.

Horizon.—Upper Permian of Warner's Bay and Belmont, N.S.W.

But for the very primitive condition of the hindwing, this genus might be assigned to the Jassidae. Recent Jassidae, however, have the hindwings very different from the tegmina, and with marked differences from the type of hindwing shown in this genus; all of them except those forms which are highly specialized by reduction have a well-developed ambient vein in the hindwing, and many have a similar vein more or less developed on the tegmen. In recent Jassid hindwings, Sc is either absent or fused with the costa; 1A and 2A are fused together basally but diverge distally, making a forked vein, and the anal area folds back just behind this vein. In the tegmen, the form of clavus shown in the fossil is almost typically Jassid, and the structure of M and Cu_1 is closely approached in several genera, but a separate R_{1a} is seldom present, and the costal space is never as broad as in the Scytinopteridae.

While retaining this genus within the Scytinopteridae for the above reasons, we may definitely indicate that the beginnings of the evolution of the enormous

recent family Jassidae are to be found in this Upper Permian Scytinopterid genus. The line of evolution can be followed straight on into the Upper Triassic of Ipswich, where we meet with two genera, *Mesojassus* and *Triassojassus* (Tillyard, 1916, p. 35 and 1919, p. 887), which are evidently direct descendants from *Permojassus* or some closely allied form; these I placed without hesitation in the Jassidae, but this decision rested only on the form of the tegmen, the hindwings not being known. The direct evolutionary line from these forms runs out in such recent genera as *Paropia* (*Megophthalmus*) and *Jassus*, the family as a whole tending towards reduction, though a few forms have added extra veinlets or cross-veins.

1. PERMOJASSUS AUSTRALIS, n. sp. (Text-figs. 2, 3.)

Tegmen 6 mm. long, 2·5 mm. wide. Costal margin very strong and stout at base, gradually narrowing to the point above end of basal cell where it bends to run parallel to the posterior margin; at this point the costal space is about 0·8 mm. wide. A weakly formed costal veinlet can just be made out arising from R_1 a little before its division into R_{1a} and R_{1b} and running transversely to the costa. M arising from R + M by a short transverse piece, and then bending strongly to run straight through the middle of the tegmen until about one-third from apex, when it divides strongly into M_{1+2} above and M_{3+4} below, the former being strongly broken not far from its origin by reception of cross-vein *rm* from Rs, the latter similarly broken by reception of cross-vein *mcu* from the fork of Cu_1; further distad, M_{1+2} forks again into M_1 and M_2 while still bounding the cell *mc*, and M_1 is similarly broken by reception of a weakly formed cross-vein from Rs. Cu_1 gently curved, the curve being continued beyond *mcu* by Cu_{1a}, with Cu_{1b} as a posterior branch. Cu_2 ending at two-thirds along posterior margin, which runs past it absolutely straight, without any break or angle in its contour. 1A diverging strongly from Cu_2 in a flatly sigmoidal curve. 2A short, enclosing the well-marked anal angle. An obverse impression, with apex to left.

Hindwing 6 mm. long, 2·6 mm. wide. Costal margin slightly curved basally, then almost straight to end of R_{1a} which is almost at the apex; costal space narrower basally than distally, not so wide as in the tegmen. No costal veinlet before R_{1a}. M free from R basally, but united with Cu, which it leaves by a slight curve just before Cu divides into Cu_1 and Cu_2, and then runs almost straight to well beyond the level of origin of Rs, when it divides into a single distal fork a little larger than that of Cu_1 below it; *rm* falls on to M_{1+2} without breaking its curve. No other cross-veins present. Posterior margin evenly curved, with perhaps a very slight break at end of Cu_2. Anal area broad, apparently folding along or slightly basad from 1A and its posterior, straight continuation; basal curved portion of 1A very strongly developed. A reverse impression, with apex to right.

Types: *Holotype tegmen*, Specimen No. 54*b*, in Mr. Pincombe's Collection; found by him at Warner's Bay, May 6th, 1923; *heautotype hindwing*, Specimen No. 56 in same collection, found at same place and time in same piece of rock not far from the tegmen. Both specimens are on a rather dark grey chert and only moderately well preserved; but with careful lighting all the veins can be made out.

2. PERMOJASSUS DUBIUS, n. sp.

A rather poorly preserved tegmen about 5 mm. long, with basal part of clavus irregularly broken off. As far as it can be made out, the general scheme of

venation is closely similar to that of the previous species, but *im* is very weakly formed and the manner of branching of M is different. An obverse impression, with apex to left.

Type: *Holotype tegmen*, Specimen No. 64 in Mr. Pincombe's Collection; found by him at Belmont in 1923 (date not given). The only record, so far, of this genus from Belmont.

Genus 2. ORTHOSCYTINA, n. g. (Text-figs. 4-12.)

Tegmen.—Costa very stout and strongly arched from base, then running absolutely straight nearly to end of R_{1b}, whence the termen or apical margin is very bluntly rounded. Clavus missing in all known specimens, broken off along the deep groove of the *vena dividens*, Cu_2. Sc present or absent. R + M arched above the basal cell; R itself, on leaving the cell, is a very strong vein running absolutely straight or with a very slight upward curve to end of R_{1a}; consequently the costal space is wedge-shaped, widest at end of cell. R_{1b} and pterostigmatic area long and flat, the latter with or without veinlets. Rs arising well before half-way along the tegmen parallel to, or slightly converging towards R_{1b}. M with its principal fork at one-third or less from apex, and having from three to five branches altogether. Cu_1 at end of cell either touching M or attached to it by a very short vein, then curving away downwards markedly so as to come close to Cu_2, then diverging from it again, and ending in three or more distal branches.

Genotype, *Orthoscytina mitchelli*, n. sp. (Belmont, N.S.W.).

Horizon.—Upper Permian of Belmont and Warner's Bay, N.S.W.

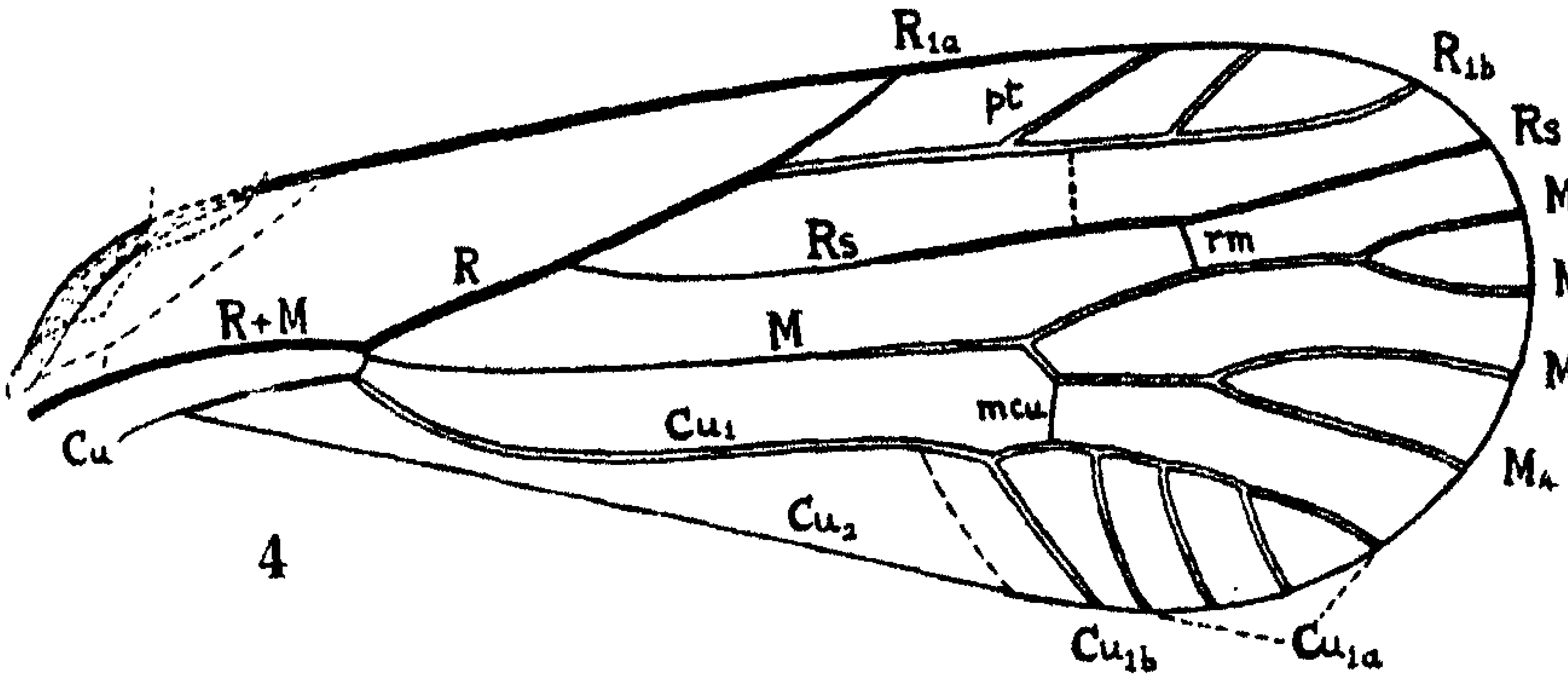
This genus is well characterized by the shape of the tegmen, the strong, straight R_1 and the strongly curved Cu_1. It appears to have been the dominant genus in the Upper Permian Homoptera, and was probably the ancestral form from which the Upper Triassic genus *Mesocixiodes* was derived. Nine species are known, one from Warner's Bay and eight from Belmont; there are also a number of fragments belonging to this genus, but too incomplete to name.

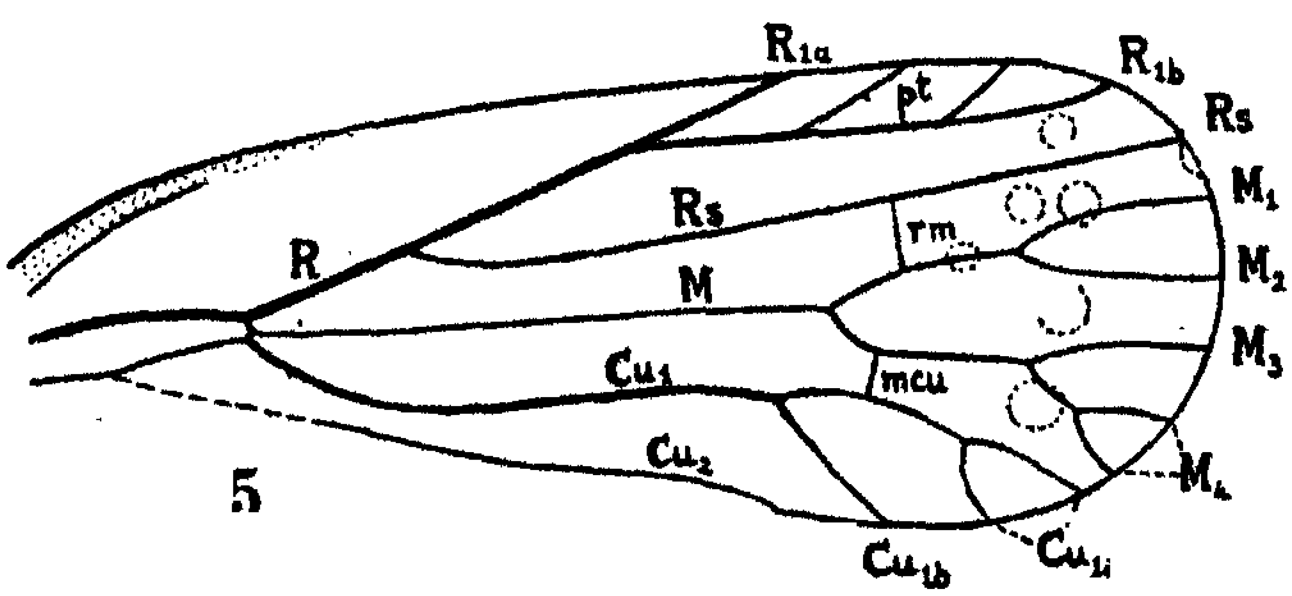
The species may be distinguished as follows:

1. Pterostigmatic area without veinlets 2
   Pterostigmatic area with one or more veinlets 4
2. Rs a straight, unbroken vein 3
   Rs bent or slightly broken at two points distally where cross-veins connect it with M_{1+2} .... *O. irregularis*, n. sp.
3. Sc complete; pterostigmatic area very long; Cu_1 with only three branches .... *O. subcostalis*, n. sp.
   Sc absent; pterostigmatic area only moderately long; Cu_1 with four or five branches .... *O. pincombei*, n. sp.
4. Pterostigmatic area with only a single veinlet 5
   Pterostigmatic area with two or three veinlets 6
5. R_{1a} parallel with the pterostigmatic veinlet and of about the same length .... *O. belmontensis*, n. sp.
   R_{1a} much more oblique than the pterostigmatic veinlet and much longer than it .... *O. obliqua*, n. sp.
6. Pterostigmatic area with three veinlets; both M and Cu_1 with four branches .... *O. tetraneura*, n. sp.
   Pterostigmatic area with only two veinlets; either M or Cu_1 or both not four-branched 7
7. Cu_1 with three branches 8
   Cu_1 with five or six branches .... *O. mitchelli*, n. sp.
8. M with three branches .... *O. indistincta*, n. sp.
   M with five branches .... *O. quinquemedia*, n. sp.

3. ORTHOSCYTINA MITCHELLI, n. sp. (Text-fig. 4.)

Tegmen 10 mm. long, greatest breadth 3·4 mm. near apex. Sc obsolescent, barely indicated as shown by the dotted line in costal space in Text-fig. 4. R absolutely straight from end of basal cell to end of R_{1a}. The whole of R_{1b} and Cu_1, and all the other veins in the distal half of the tegmen slightly flattened, giving a double outline in the fossil. Pterostigmatic veinlets not at equal intervals and not parallel, the first and second converging towards the costa. *Rs slightly curved* downwards near origin, very slightly broken at *rm*, slender basally, thickened and flattened distally. M slender basally, thickened and flattened well before its principal fork; branching dichotomically into four distally, the fork of M_{1+2} much smaller than that of M_{3+4}; the stem of the latter vein strongly bent at *mcu*. Cu_1





Text-fig. 4. *Orthoscytina mitchelli*, n.g. et sp., family Scytinopteridae; Upper Permian of Belmont. Tegmen. Length 10 mm. Lettering as in Text-fig. 1.

Text-fig. 5. *Orthoscytina quinquemedia*, n. sp., family Scytinopteridae; Upper Permian of Warner's Bay. Tegmen. Length 8 mm. Lettering as in Text-fig. 1.

a very strong vein throughout, forking into Cu_{1b} and Cu_{1a} a little before *mcu*; Cu_{1a} having a pectinate series of three branches descending from it. All these branches can be clearly seen as flat veins with double outline if the light be carefully arranged; there are also slight indications of an anterior branch before Cu_{1b} (marked by a dotted line in Text-fig. 4) but this is not certain. Clavus absent. A greyish tegmen on a hard chert of the same colour; obverse, with apex to right.

Type: *Holotype tegmen*, Specimen No. 114 in Mr. Mitchell's Collection; found by him at Belmont in 1925.

This specimen is the best preserved of the eight species so far discovered at Belmont, and is selected as the type for that reason. The Warner's Bay specimen, *O. quinquemedia*, n. sp., is also extremely well preserved, but in all the other species portions of the venation are very faint.

4. ORTHOSCYTINA QUINQUEMEDIA, n. sp. (Text-fig. 5.)

Tegmen 8 mm. long, greatest breadth 2·6 mm. near apex. Sc entirely absent. R absolutely straight from end of basal cell to end of R_{1a}. Pterostigmatic veinlets arranged at equal intervals along R_{1b}, subparallel to R_{1a}, but much more weakly formed than that vein. Rs slightly curved downwards near origin, then running straight to apical border, converging towards R_{1b}. M arising from R + M by a very short oblique piece, then running straight through middle of tegmen to its principal fork; the five branches of M are M_1, M_2, M_3 and two short ones on M_4; no closed median cell. Cross-veins *rm* and *mcu* present but weakly formed, not breaking the curves of the veins to which they are attached. First forking of Cu_1 at a level slightly basad from that of M; second fork placed distally on Cu_{1a}. Clavus absent. Tegmen darker than the rather dark grey chert on which it is impressed, possibly indicating that it was deeply pigmented in life. An obverse impression, with apex to right.

Type: *Holotype tegmen*. Specimen No. 69 in Mr. Pincombe's Collection; found by him at Warner's Bay, July 21st, 1923.

This specimen is the best preserved representative of the genus yet found, and is selected as the genotype for that reason; in the other species, portions of the venation are very faint.

5. ORTHOSCYTINA INDISTINCTA, n. sp. (Text-fig. 6.)

Tegmen 9·3 mm. long; greatest width 3·7 mm. A very smooth, indistinct impression on a pale greyish chert, the venation difficult to follow except under strong, oblique light. Sc absent. It differs from the previous species in its larger size, in the slight upward curving of R from end of basal cell to end of R_{1a}, in the irregular arrangement and obliquity of the two pterostigmatic veinlets, in having Rs arising much closer to R_{1b}, and in M being only three-branched, the branches being M_{1+2}, M_3 and M_4; *rm* is absent, *mcu* present, and there is no closed median cell. Obverse impression, with apex to left.

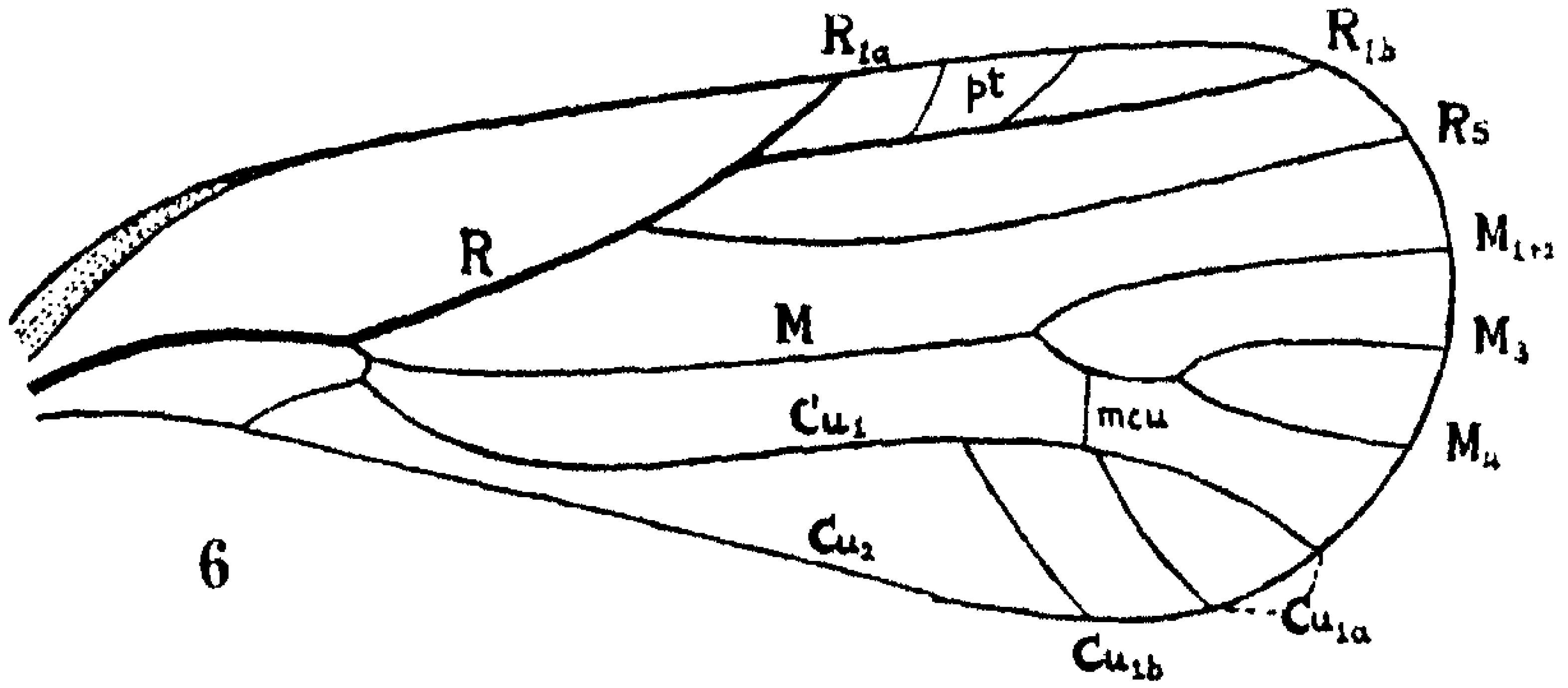
Type: *Holotype tegmen*, Specimen No. 70 in Mr. Mitchell's Collection, found by him at Belmont in 1922.

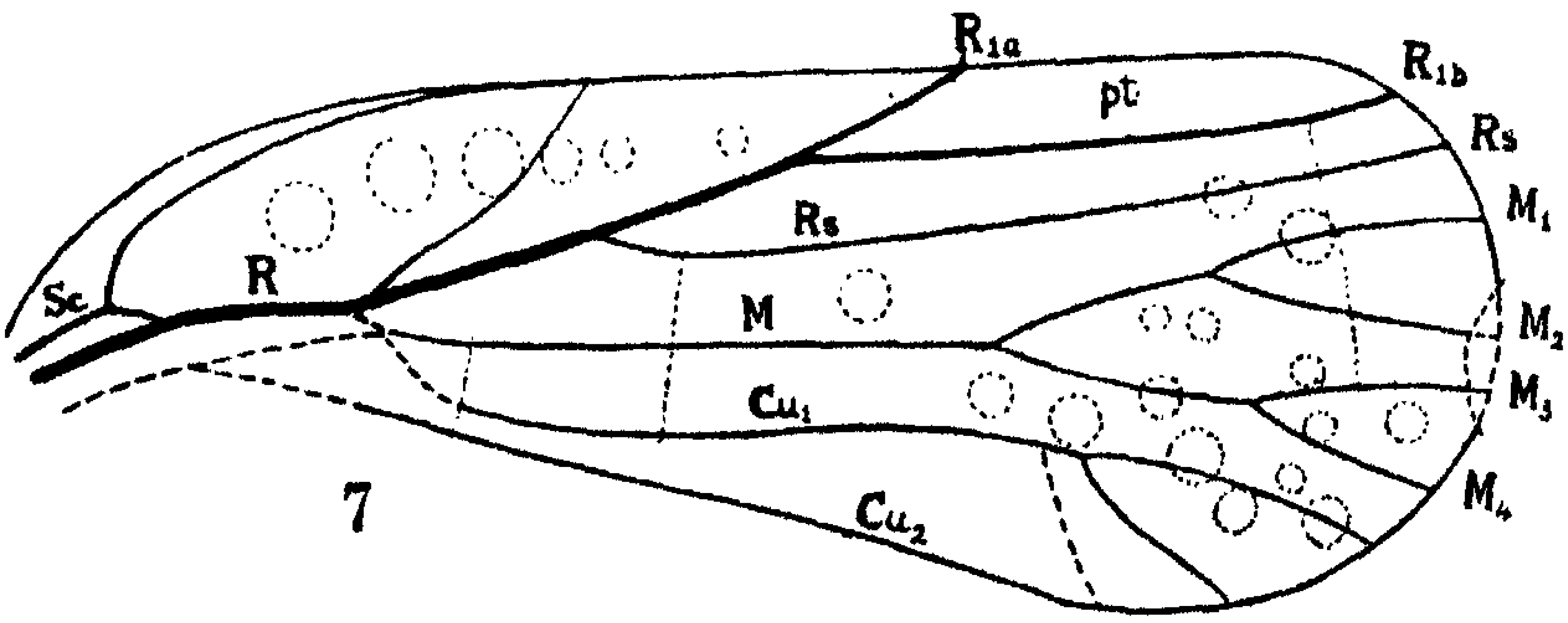
6. ORTHOSCYTINA SUBCOSTALIS, n. sp. (Text-fig. 7.)

Tegmen 9·2 mm. long; greatest breadth 3·7 mm. A rather dark impression on a greyish chert; venation fairly well preserved. In costal space and scattered about on the distal portion also are to be seen circular disc-like impressions, some of them of a paler colour than the rest of the tegmen. These seem to have no relationship to the venation, and are probably the results of bubbles of air or gas having got caught beneath the tough tegmen when settling down in the mud; a few less clearly marked ones are to be seen also on the tegmen of *O. quinquemedia*, n. sp. (Text-fig. 5), and I have seen them on other specimens also. Sc apparently forming a short closed cell basally above R + M and giving off an upwardly curving branch running beneath and converging towards the arched basal part of the costa, which it reaches at about one-third from base. Costal space with a single oblique veinlet arising just beyond end of basal cell, very weak. Pterostigmatic space without veinlets. Rs arising about midway between R_{1b} and M, slightly curved at

first, then running straight and converging slightly towards R_{1b}. M with four branches, arranged dichotomically, and no closed median cell. Distal end of Cu_1 not well preserved, the rock being rough there; actual course of Cu_{1b} not clearly to be made out, but probably as shown by the dotted line in Text-fig. 7. Obverse with apex to left.

Type: *Holotype tegmen*, with counterpart. Specimen No. 4 in Mr. Pincombe's collection; found by him at Belmont in 1922.





Text-fig. 6. *Orthoscytina indistincta*, n. sp., family Scytinopteridae; Upper Permian of Belmont. Tegmen, with apex turned to right. Length 9·3 mm. Lettering as in Text-fig. 1.

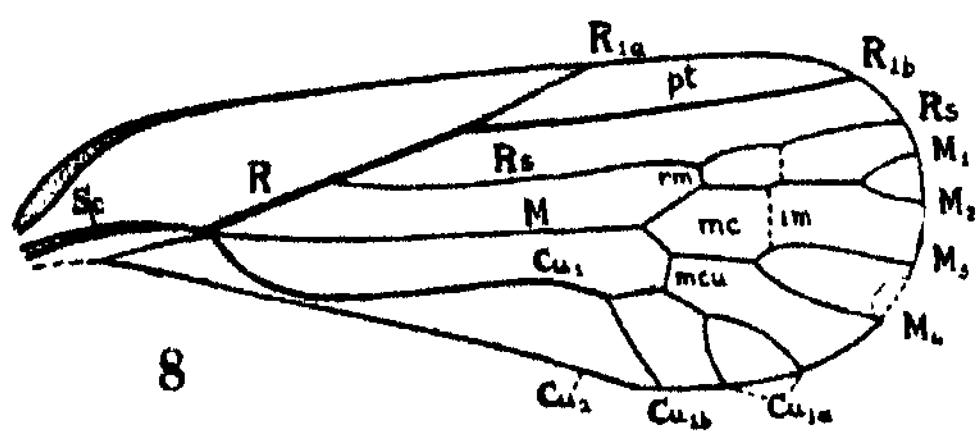
Text-fig. 7. *Orthoscytina subcostalis*, n. sp., family Scytinopteridae; Upper Permian of Belmont. Tegmen, with apex turned to right. Length 9·2 mm. Lettering as in Text-fig. 1.

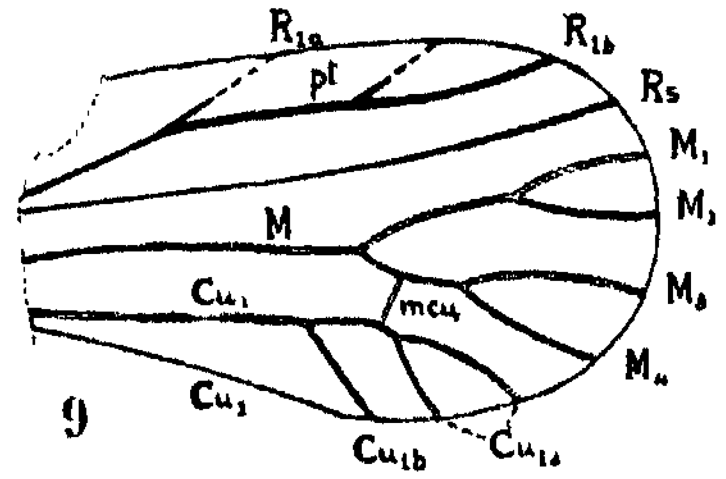
7. Orthoscytina irregularis, n. sp. (Text-fig. 8.)

Tegmen 8·6 mm. long; greatest breadth 3 mm. A rather weak, buff-coloured impression on a greyish-buff chert, the venation requiring careful lighting to follow out. Sc apparently present only as a weak vein running just above $R + M$ and fusing with it towards end of basal cell; costa very strongly formed and greatly curved basally. R absolutely straight from cell to end of R_{1a}. Pterostigmatic area without veinlets. Rs arising about midway between R_{1b} and M, very slightly curved basally, subparallel to R_{1b}; its course definitely broken at cross-vein *rm* and again very slightly at a second weaker cross-vein placed more distally below it. R, M and Cu_1 apparently all arising from basal cell at same point. M four-branched, but the distal fork of M_{1+2} very small; this vein is strongly broken

at *rm* and again at two nearly coincident, weaker cross-veins above and below it more distally; of these, the lower is the intermedian, *im*, so that a weakly closed median cell (*mc*) is present. Cross-vein *mcu* strongly formed, bending both M_{3+4} and Cu_{1a} markedly where it meets them. Obverse impression with apex to left.

Type: *Holotype tegmen* and counterpart in Cawthron Institute Collection, on two narrowly wedge-shaped pieces of rock (label "R.J.T., 12.xi.21"), found by myself, at Belmont, Nov. 12th, 1921.





Text-fig. 8. *Orthoscytina irregularis*, n. sp., family Scytinopteridae; Upper Permian of Belmont. Tegmen, with apex turned to right. Length 8·6 mm. Lettering as in Text-fig. 1.

Text-fig. 9. *Orthoscytina belmontensis*, n. sp., family Scytinopteridae; Upper Permian of Belmont. Tegmen, with apex turned to right. Length of fragment, 4·9 mm. Lettering as in Text-fig. 1.

8. ORTHOSCYTINA BELMONTENSIS, n. sp. (Text-fig. 9.)

Tegmen (apical two-thirds only) 4·9 mm. long, representing a total length of about 7·4 mm.; greatest breadth 2·8 mm. The impression is a reverse one, with apex to left, beautifully preserved. R_{1a} and the single pterostigmatic veinlet are both very strong basally, but become somewhat indistinct and weak distally; R_{1b} is a strong, broad vein right to apex. Rs weakly formed except apically, where it tends to become flattened. All the other veins except Cu_2 are flattened, with a double outline. M four-branched, the fork of M_{1+2} somewhat smaller than of M_{3+4}; no closed median cell present. Cross-vein *rm* absent; *mcu* present, from M_{3+4} on to Cu_{1a} just before its fork.

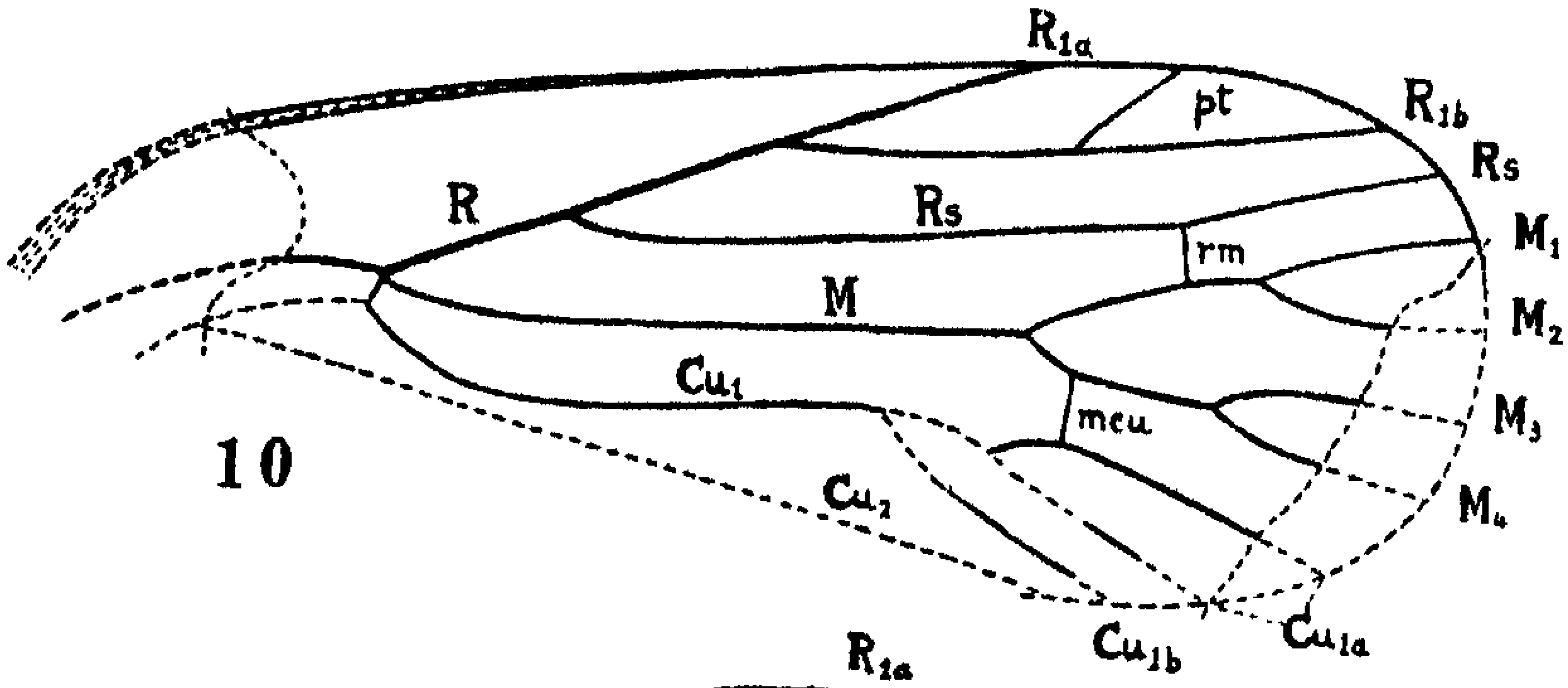
Type: *Holotype tegmen*. Specimen No. 2T in Mr. Pincombe's Collection; found by him at Belmont, February 2nd, 1922.

9. ORTHOSCYTINA OBLIQUA, n. sp. (Text-fig. 10.)

Tegmen with the basal portion, including most of the basal cell, missing, also portion of the apical margin from M_1 to Cu_{1a} obliquely; length of fragment 7·6 mm., indicating a tegmen of total length about 9 mm.; greatest breadth 3·2 mm. A greyish impression on paler and somewhat irregular chert; the courses of Cu_2 and portions of the branches of Cu_1 obliterated; reverse, with apex to right. This species resembles *O. belmontensis*, n. sp., in having only one pterostigmatic veinlet, but differs from it in the marked obliquity of R_{1a} and its consequent much greater length than usual in this genus. Rs is slightly bent at *rm*, and the two apical forks of M are almost equal in size. Cu_1 is apparently three-branched, but the exact courses of the branches are not clearly visible. R + M, R, R_{1a}, R_{1b} and main stem of Cu_1 are strong, stout veins, the rest rather weak.

Type: *Holotype tegmen*, Specimen No. 112 in Mr. Mitchell's Collection; found by him at Belmont, 1925.

Two slightly smaller tegmina from Belmont may be provisionally placed in this species, though they are not sufficiently well preserved to make their identity quite certain; these are Specimen No. 63 (T. H. Pincombe, September, 1923) and No. 102 (J. Mitchell, undated). Both show the single pterostigmatic veinlet and the very oblique R_{1a}.



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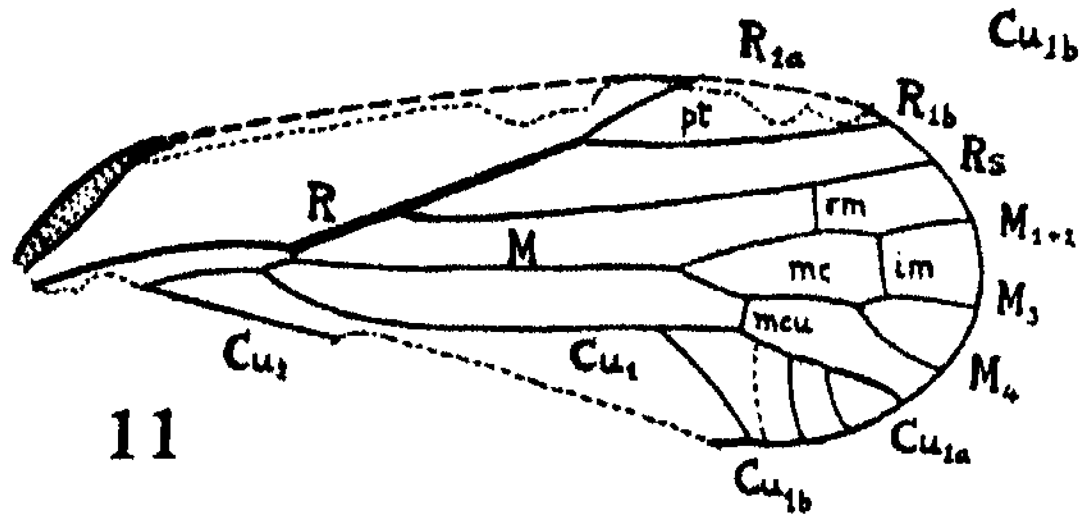

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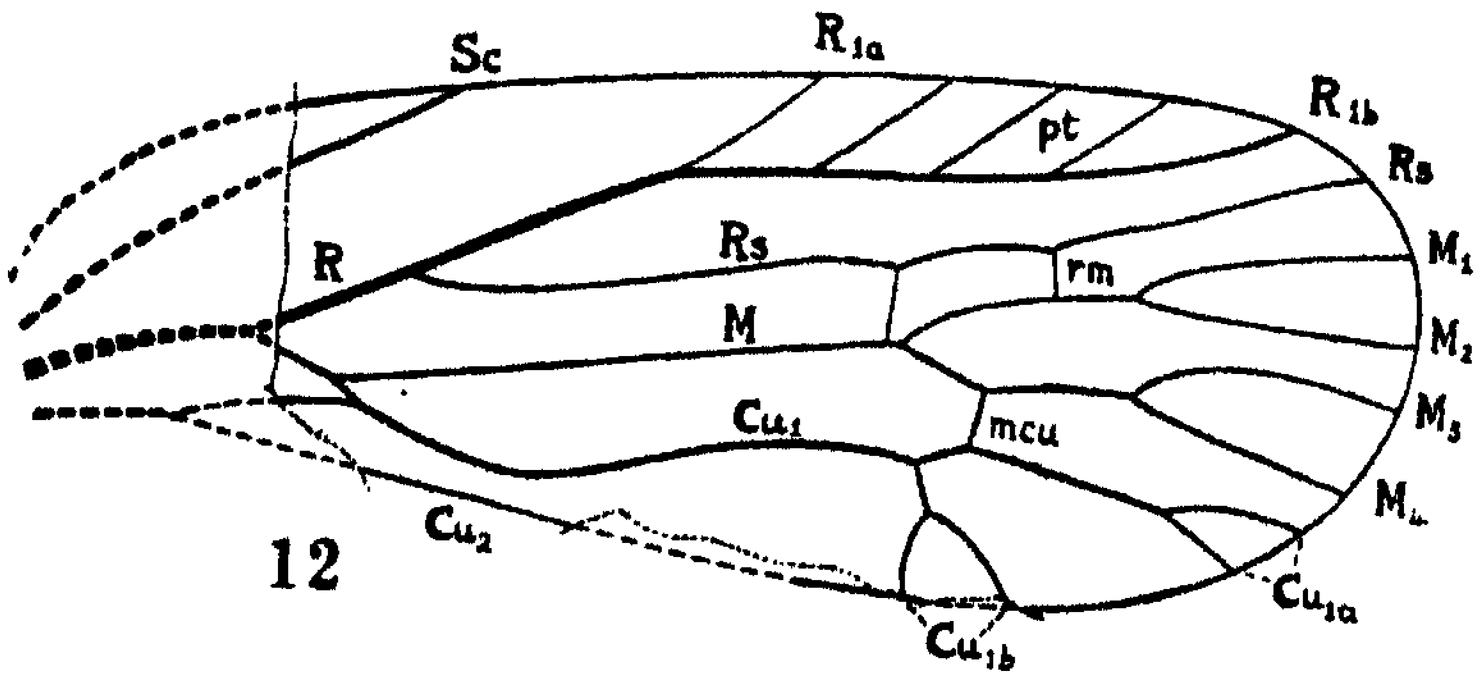

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Text-fig. 10. *Orthoscytina obliqua*, n. sp., family Scytinopteridae; Upper Permian of Belmont. Tegmen. Length of fragment, 7·6 mm. Lettering as in Text-fig. 1.

Text-fig. 11. *Orthoscytina pincombei*, n. sp., family Scytinopteridae; Upper Permian of Belmont. Tegmen. Length 7 mm. Lettering as in Text-figs. 1 and 2.

Text-fig. 12. *Orthoscytina tetraneura*, n. sp., family Scytinopteridae; Upper Permian of Belmont. Tegmen, with apex turned to right. Length of fragment, 7 mm. Lettering as in Text-fig. 1.

10. ORTHOSCYTINA PINCOMBEI, n. sp. (Text-fig. 11.)

Tegmen 7 mm. long; greatest breadth 2·6 mm. A rather dark impression on median grey chert; obverse, with apex to right. Costal margin broken away irregularly except at base. R_{1a} not quite in line with R_1. Rs arising well before

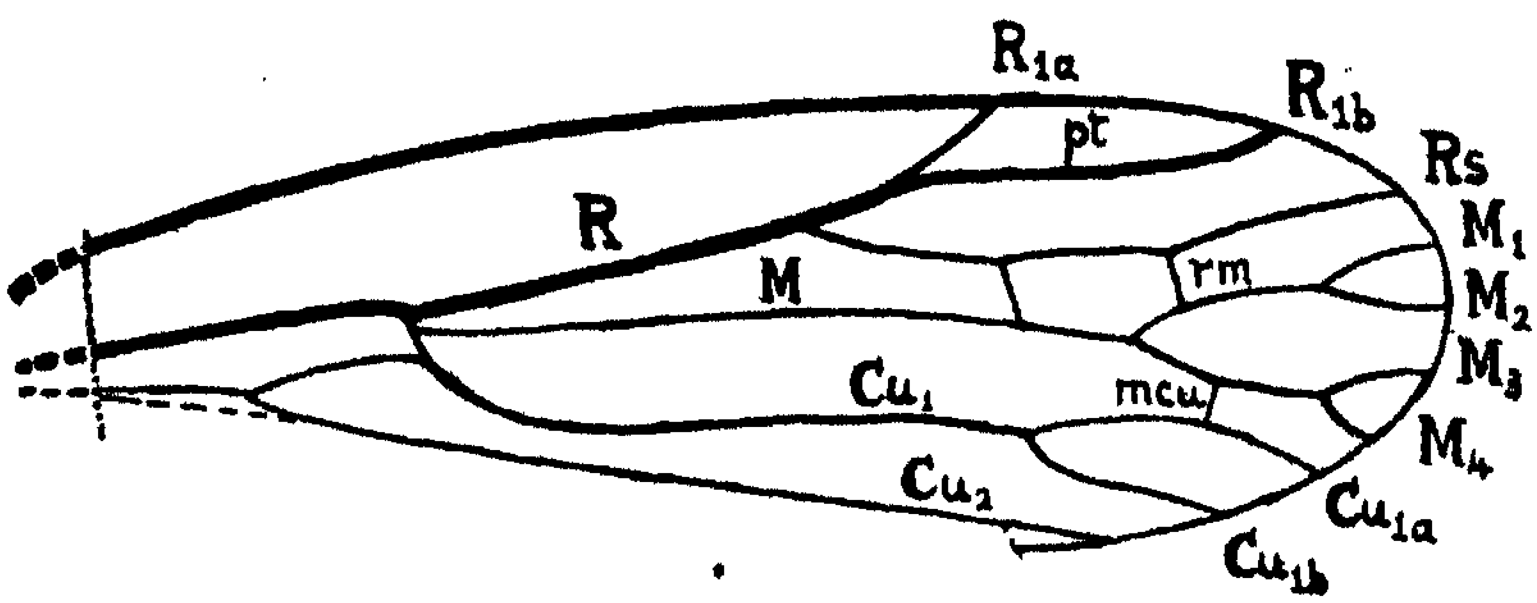
half-way, closer to M than to R_{1b} and converging slightly towards the latter distally. Pterostigmatic area less elongated than in the other species, without any veinlets. Apical border of tegmen somewhat less bluntly rounded than in the other species. Rs arising well before half-way, closer to M than to R_{1b} and converging slightly towards the latter distally. M with three branches, M_{1+2}, M_3 and M_4, and having a median cell (*mc*) closed distally by the intermedian cross-vein *im* falling on to M_3. Cross-veins *rm* and *mcu* both present. Cu_1 with four or possibly five branches (one very indistinct), the extra branches forming a pectinate series on Cu_{1a} as in *O. mitchelli*, n. sp. Most of Cu_2 missing.

Type: Holotype tegmen, Specimen No. 143 and counterpart No. 107 (not seen) in Mr. Pincombe's Collection; found by him at Belmont, Feb. 24th, 1925.

11. ORTHOSCYTINA TETRANEURA, n. sp. (Text-fig. 12.)

Tegmen: Length of fragment 7 mm., indicating a total length of about 8·5 mm.; greatest breadth 3·2 mm. A reverse impression, greyish-buff in colour, on a greyish-white chert, with apex to left. Besides the whole of the clavus and a portion of Cu_2, the whole of the base is missing up to origin of M. Sc is preserved distally for a short distance as a vein quite distinct from costa, ending up at about level of origin of Rs. R_{1a} a weak vein, exactly similar to the three pterostigmatic veinlets which follow it; these latter are evenly placed, oblique and parallel to one another. Rs slightly waved, converging towards R_{1b} distally, slightly broken in two places where *rm* and a more basally placed cross-vein connect it with M. Distal forks of M about equal; stem of M_{3+4} broken where it receives *mcu*, as is also the stem of Cu_{1a} below it. No closed median cell. Cu_1 with four branches, arranged dichotomically. Cu_{1b} arises at level of principal fork of M and its stem is placed much more transversely than usual; its apical fork is slightly larger than that of Cu_{1a}, much smaller than those of M.

Type: *Holotype tegmen*, Specimen No. 7T in Mr. Pincombe's Collection; found by him at Belmont, July 14th, 1922.



Text-fig. 13. *Stenoscytina australiensis*, n.g. et sp., family Scytinopteridae; Upper Permian of Belmont. Tegmen. Length 7·2 mm. Lettering as in Text-fig. 1.

Genus 3. STENOSCYTINA, n. g. (Text-fig. 13.)

A genus somewhat of the type of *Orthoscytina*, n. g., but having the tegmen much narrower, R curving gently upwards to end of R_{1a}, the pterostigmatic region not so markedly elongated, the costa evenly curved from base to apex. Rs arises well beyond half-way, fairly close to R_{1b}. M four-branched, the apical forks being dichotomically arranged and small. Cu_1 curves markedly downwards on leaving

basal cell, so as to come close to Cu_2, then diverges from it again and has a single large apical fork. Cu_2 ends on posterior margin at about three-fourths of wing-length. Clavus missing, but evidently narrower than usual for the family.

Genotype, *Stenoscytina australiensis*, n. sp.

Horizon.—Upper Permian of Belmont, N.S.W.

12. STENOSCYTINA AUSTRALIENSIS, n. sp. (Text-fig. 13.)

Tegmen 7·2 mm. long, with extreme base broken off, representing a total length of about 7·6 mm.; greatest breadth 2·4 mm.

R + M nearly straight, making the costal space of more even width basally than usual in the family. No pterostigmatic veinlets present. Rs slightly broken at two places where cross-veins pass from it to M, viz. *rm* on to M_{1+2} and a more basal one on to main stem of M; the latter is slightly curved upwards towards Rs about the middle. No closed median cell present; *mcu* present, from middle of M_{3+4} to about middle of Cu_{1a}. Apical fork of Cu_1 rather long and narrow. A reverse impression in fair condition, apex to right.

Type: *Holotype tegmen*, Specimen No. 77 in Mr. Mitchell's Collection; found by him at Belmont in 1922.

Genus 4. HOMALOSCYTINA, n. g. (Text-fig. 14.)

This is the first of a group of genera in the tegmina of which R_{1a}, instead of being in line with R_1, makes a marked angle with it, being much more transversely placed. Costa strongly curved basally, slightly curved distally, termen or apical margin rather bluntly rounded. Pterostigmatic area moderately long. Rs arising well beyond half-way. M four-branched, Cu_1 two-branched, running straight from basal cell to fork.

Genotype, *Homaloscytina plana*, n. sp.

Horizon.—Upper Permian of Warner's Bay, N.S.W.

13. HOMALOSCYTINA PLANA, n. sp. (Text-fig. 14.)

Tegmen 6·4 mm. long; greatest breadth 2·7 mm. A fair obverse impression with apex to right, venation weak, colour dark grey on a medium grey chert. No pterostigmatic veinlets present. Rs arising much closer to R_{1b} than to M, diverging slightly from R_{1b} distally. Forks of M dichotomically arranged, that of M_{1+2} smaller than that of M_{3+4}; *mcu* the only cross-vein present, causing a marked break in M_{3+4} where it meets it. Cu_1 running straight from basal cell to end of Cu_{1a}, with Cu_{1b} as a posterior branch. Cu_2 parallel with Cu_1, ending at about two-thirds along posterior margin. Basal cell broader than usual for the family.

Type: *Holotype tegmen*, Specimen No. 59 in Mr. Pincombe's Collection; found by him at Warner's Bay on December 1st, 1923.

Genus 5. ELLIPTOSCARTA, n. g. (Text-fig. 15.)

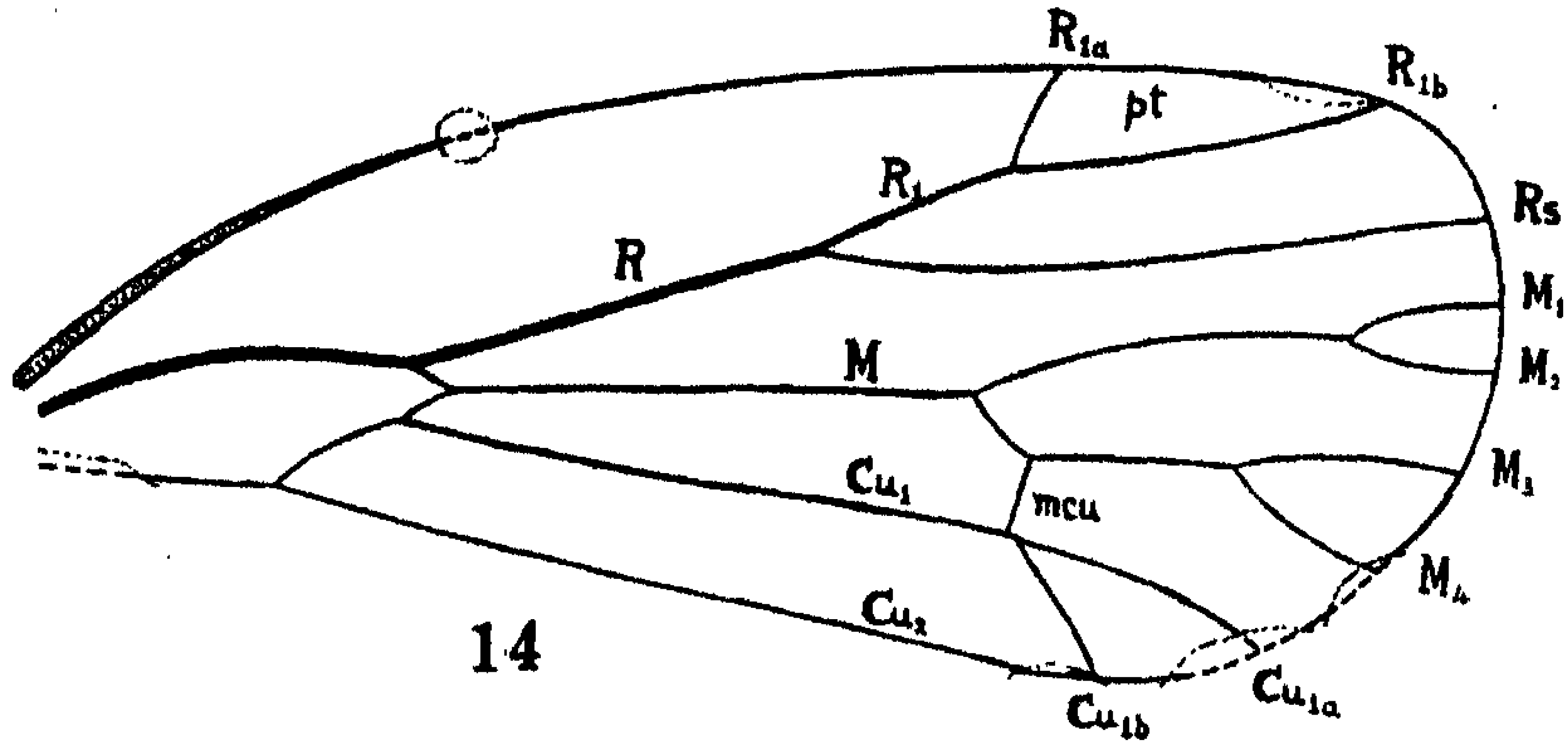
Tegmen broadly oval, with wide costal space. Pterostigmatic area short, its length along costa only about equal to the length of R_{1a}; forking of R_1 dichotomic. Rs arises a little beyond middle much nearer to R_{1b} than to M. M five-branched. Cu_1 three-branched (the course of its main stem missing in the fossil).

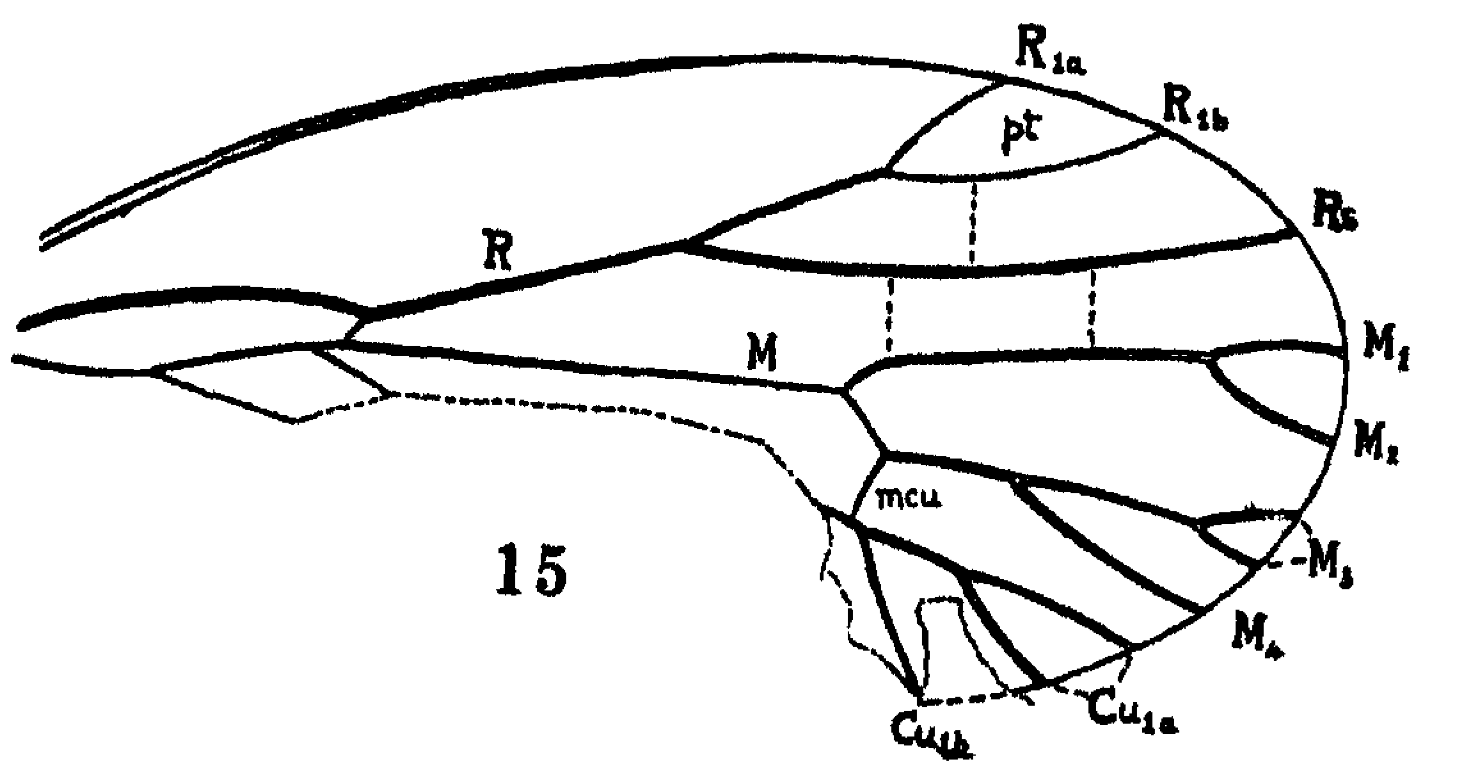
Genotype, *Elliptoscarta ovalis*, n. sp.

Horizon.—Upper Permian of Belmont, N.S.W.

14. ELLIPTOSCARTA OVALIS, n. sp. (Text-fig. 15.)

Tegmen 5·3 mm. long, greatest breadth 2·4 mm. A darkish reverse impression, with apex to right, on medium grey chert; venation moderately clear. Apical veins, from Rs to Cu_{1b}, tending to become flattened, giving a double outline in the fossil. A large break has carried away not only the clavus but a considerable area above it, including all but the basal parts of Cu_2 and main stem of Cu_1. Rs





Text-fig. 14. *Homaloscytina plana*, n.g. et sp., family Scytinopteridae; Upper Permian of Warner's Bay. Tegmen. Length 6·4 mm. Lettering as in Text-fig. 1.

Text-fig. 15. *Elliptoscarta ovalis*, n.g. et sp., family Scytinopteridae; Upper Permian of Belmont. Tegmen. Length 5·3 mm. Lettering as in Text-fig. 1.

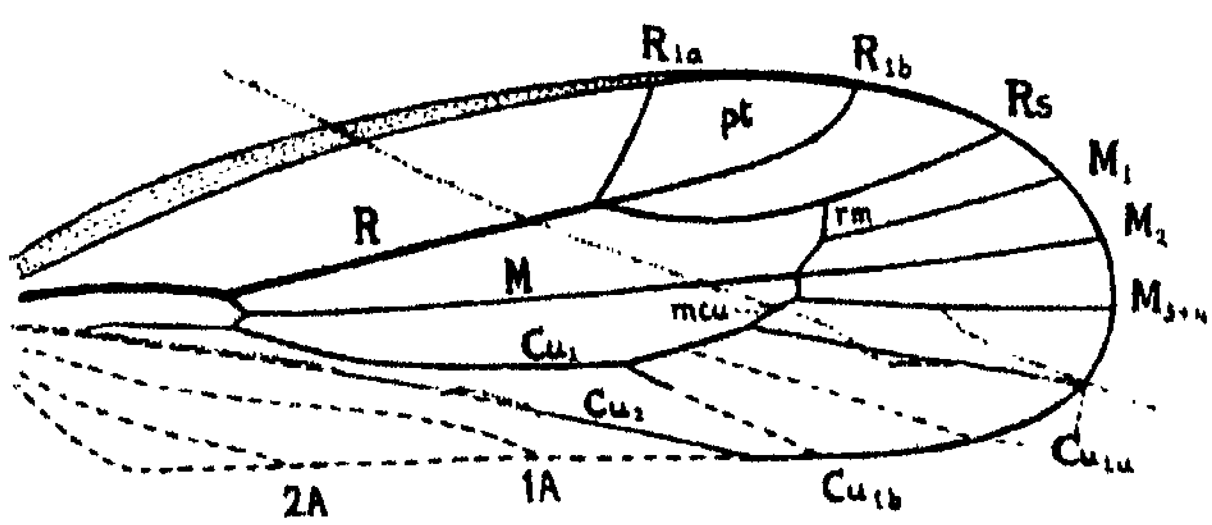
slightly curved, diverging slightly from R_{1b} distally. M running straight through middle of tegmen, forking a little before one-third from apex; its five apical branches are M_1, M_2, two short branches on M_3, and a fairly long M_4; the only clear cross-vein is *mcu*, which breaks the line of M_{3+4} very strongly where it arises, but there are slight indications of three much weaker cross-veins in the positions indicated by dotted lines in Text-fig. 15. Cu_{1b} arises just distad from *mcu*; Cu_{1a} has an apical fork.

Type.—*Holotype tegmen*, Specimen No. 150 in Mr. Pincombe's Collection; found by him at Belmont, February 23rd, 1925.

In its small size, well rounded shape and flattening of the distal veins, this tegmen shows a distinct approach to the very small Sternorrhynchous forms described below, and undoubtedly indicates the line of evolution in these characters which led to that Division. In its venation and in the great breadth of its costal space, the fossil belongs to the Scytinopteridae; it would be very interesting to discover the clavus and to see whether it had begun to undergo any reduction.

Genus 6. ACTINOSCYTINA, n. g. (Text-fig. 16.)

A somewhat isolated type in which the tegmen is distinguished at once by having the origin of Rs and R_{1a} at the same point on R, beyond half-way, and by the arrangement of the distal branches of M and Cu as straight, slightly diverging rays. Costal strongly arched from base to apex, very stout, especially from base to R_{1a}. Pterostigmatic area short and deep, with R_{1a} very transversely placed and nearly as long as the distance from it to R_{1b} on the costa. M running straight through middle of wing to end of M_2. Cu_1 curved concavely to M,



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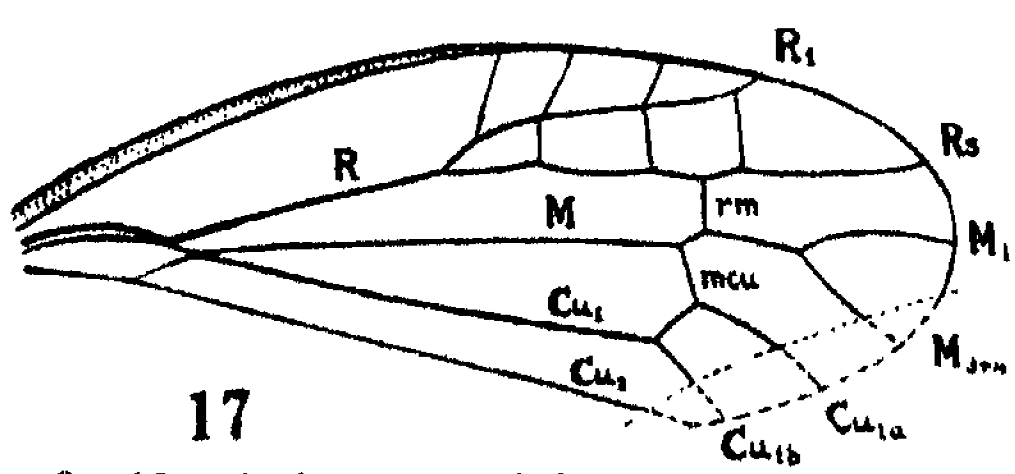

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Text-fig. 16. *Actinoscytina belmontensis*, n.g. et sp., family Scytinopteridae; Upper Permian of Belmont. Tegmen, with apex turned to right. Length 7 mm. Lettering as in Text-fig. 1.

Text-fig. 17. *Permoscarta trivenulata*, n. sp., family Scytinopteridae; Upper Permian of Warner's Bay. Tegmen, with apex turned to right. Length 6 mm. Lettering as in Text-fig. 1.

approaching very close to Cu_2 at a point not far from basal cell. M and Cu_1 each with three distal branches, arranged at about equal intervals as diverging rays to the wing-margin. Posterior margin distally very straight, suggesting that the missing clavus was of the form shown by the dotted lines in Text-fig. 16.

Genotype, *Actinoscytina belmontensis*, n. sp.

Horizon.—Upper Permian of Belmont, N.S.W.

15. ACTINOSCYTINA BELMONTENSIS, n. sp. (Text-fig. 16.)

Tegmen 7 mm. long; greatest breadth 2·4 mm. A medium greyish impression on chert of the same colour, obverse, with apex to left; venation fairly clear. The

tegmen is damaged by a slight crack running obliquely across it as shown in Text-fig. 16, and by abrasions of the rock which partially obliterate the courses of the branches of Cu_1. R_{1b} curving strongly upwards to costa. Cross-veins *rm* and *mcu* combine with bent basal pieces of M_1, M_{3+4} and Cu_{1a} to form an irregular but complete *transverse cord*, of the type found in many Perlaria and Trichoptera, running from origin of Cu_{1b} right up to Rs and forming the distal boundary of a large central cell bounded anteriorly by R and Rs, posteriorly by Cu_1, and divided into two by the straight vein M. From this cell the distal veins radiate out to the margin.* In Text-fig. 16 the restored clavus is shown by dotted lines, as are also the two lower branches of Cu_1 which are almost obliterated in the fossil.

Type.—*Holotype tegmen*, Specimen No. 85 in Mr. Pincombe's Collection; found by him at Belmont, August 8th, 1924.

Genus 7. PERMOSCARTA Till. (Text-fig. 17.)
Tillyard, 1918, p. 726.

This genus was proposed by me for the reception of a small tegmen found by Mr. Mitchell in shale just above the Dirty Seam, Newcastle, N.S.W., which I named *Permoscarta mitchelli* and placed in the family Cercopidae owing to its resemblance to the tegmen of the recent genus *Eoscarta*. It seems quite clear that the Cercopidae are directly descended from the Scytinopteridae, and that the group of genera of which *Eoscarta* is a representative must have evolved from forms resembling *Permoscarta*. The latter, however, is a true Scytinopterid in all but the loss of a definite R_{1a}, and I have already (1919, pp. 868, 875) removed it to that family.

This genus stands well apart from all other Upper Permian genera of the family in the complete loss of a definite R_{1a}. R forks only once, at a point before half-way along the tegmen, into R_1 (equivalent to R_{1b} in other forms) and Rs, *the two branches being connected by a series of inter-radial cross-veins*, not found in any other genus. Rs continues the line of R distally, while R_1 arches up as an anterior branch; between it and the costa is a series of veinlets of which the first is probably the reduced R_{1a} and the others pterostigmatic veinlets. M and Cu_1 are straight veins diverging from the basal cell and only branching far distally; both have only two branches. Cross-veins *rm* and *mcu* are present.

Genotype, *Permoscarta mitchelli* Till.

Horizon.—Upper Permian of Newcastle and Warner's Bay, N.S.W.

The two known species may be distinguished as follows:

Seven costal veinlets above R_1; six inter-radial cross-veins; M with more than two distal branches .... *P. mitchelli* Till.

Three costal veinlets above R_1; three inter-radial cross-veins; M with only two distal branches .... *P. trivenulata*, n. sp.

16. PERMOSCARTA MITCHELLI Till.
Tillyard, 1918, p. 728.

In this species R_1 arises at a point not far distad from end of basal cell; the first costal veinlet slants somewhat backwards from R_1 to costa, the second is transverse and the rest slant forwards towards the apex. M is slightly bent at *mcu*

* Compare with this formation the closely similar one found in most Lepidoptera, where, however, the main stem of M becomes obsolete in all but the more archaic families.

and again at *rm* and ends in a tiny distal fork; Cu_{1a} is strongly broken where *mcu* falls upon it; distal fork of Cu_1 small, but considerably larger than that of M.

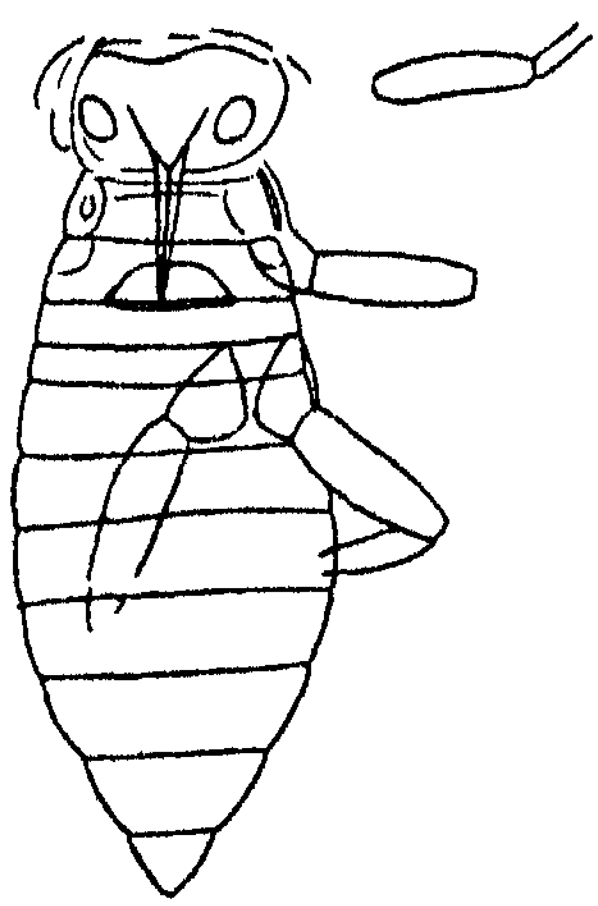
Type: *Holotype tegmen*, Specimen No. 23 in Mr. Mitchell's Collection; found by him in shale above Dirty Seam, Newcastle.

17. PERMOSCARTA TRIVENULATA, n. sp. (Text-fig. 17.)

Tegmen 6 mm. long; greatest breadth 2·1 mm. A somewhat dark obverse impression, with apex to left, on greyish chert; clavus and posterior part of termen missing. Sc apparently present as a short, separate vein just above R + M. Costa very stout, well arched from base to apex. R forking not much before half-way, R_1 arching upwards and slightly sigmoidally curved, giving off three costal veinlets all of which slant slightly forwards towards apex. Rs diverging from R_1, ending up a little before apex; three inter-radial cross-veins unite R_1 with Rs, the latter vein being slightly bent at the point of union with each cross-vein and also at origin of *rm*. M markedly bent at both *mcu* and *rm*, the latter being slightly more distally placed than the former; apical fork of M much larger than in *P. mitchelli* Till., somewhat longer than the main stem from *rm* to fork. Fork of Cu_1 a little larger than that of M; the curve of Cu_{1a} strongly broken where it receives *mcu*.

Type: *Holotype tegmen*, Specimen No. 82 in Mr. Pincombe's Collection; found by him at Warner's Bay, July 14th, 1923.

Besides the above, Specimen No. 50 in Mr. Pincombe's Collection, found at Belmont, March 18th, 1923, represents the body of a Homopterous insect, almost certainly a Scytinopterid, 5 mm. long, dorso-ventral impression. The outline



Text-fig. 18. Body of a Scytinopterid, from Upper Permian of Belmont. Length, 5 mm.

is rather faint, but the head and eleven segments can be seen, these being, as far as I can make out, the meso- and metathorax and nine abdominal segments; the prothorax is probably covered by the head. The antennae are missing, but the compound eyes can be seen, fairly wide apart; in between them is a triangular piece from which the beak projects backwards to the distal end of the metathorax. The legs have become detached from the body, but four of them are still present

in part, viz. a femur and part of the tibia of a foreleg, displaced to the right of the head, a coxa and femur of a middle leg, the former overlying the right margin of the metathorax with the femur projecting at right angles to it, and the two hindlegs with their rather large, trapezoidal coxae nearly contiguous, lying upon the right half of abdominal segments 2-3, the broad femora attached to them, and a part of the right tibia also present at an angle to the femur. General shape of body broadly fusiform, the head a little wider than the mesothorax, the abdomen widest at seg. 5, tapering to a conical end-segment. Text-fig. 18 is a somewhat diagrammatic representation of this fossil.

Family **Prosbolidae.**

The fossils included in this family are usually of considerably larger size than the Scytinopteridae; the tegmina are broad, with strong costal margin, wide costal space and strong radius. The basal cell is either very short, or else elongated and very narrow. The costa may be notched either at or before the apex of R_{1a}, forming a kind of nodus. Rs is distally branched. There is a differentiation in the texture of the membrane of the basal and distal portions of the tegmen, the basal portion being markedly tougher than the distal, sometimes granulate or tuberculate; a more or less distinct line of demarcation can be made out between the two portions, as in recent Tropiduchidae. The softness of the distal membrane sometimes results, during fossilization, in tearing or crumpling of that part, so that the impression is incomplete, worn or buckled distally. The clavus has the two anal veins widely separated from one another. The hindwings are broadly oval, with exceedingly strong radius and first cubitus, Rs distally branched, the anal area not very large and only slightly folded.

This family appears to have been ancestral to recent Fulgoroidea, the connection being closest with the Tropiduchidae. The most perfect of the new fossil tegmina shows a rounded swelling at the base of the costa, very suggestive of the tegula characteristic of the Fulgoroidea. Almost all recent Fulgoroidea have the two anal veins fusing distally to form a Y-vein. An examination of the clavus in Prosbolidae shows that 1A is already in position for this, curving towards 2A a little beyond half-way, and then converging strongly towards Cu_2 and nearly meeting it distally; the Y-vein is completed by 2A turning distally away from the margin towards the curved part of 1A and fusing with it.

The peculiar tendency towards a division of the tegmen into two very distinct parts, a basal *corium* and a distal *membrane*, which becomes a diagnostic character for the whole Suborder Heteroptera seems to crop up to a greater or less extent in various groups of Homoptera also, e.g. in many Cicadidae, in the Tropiduchidae, and in this fossil family Prosbolidae. The question might be asked, why are these fossils not classified as true Heteroptera? The answer is that, in true Heteroptera, the form of the clavus is very different from that of the Auchenorrhyncha, being correlated with the manner of folding the hemielytra flatly down on the abdomen with their distal portions completely overlapping; there is, consequently, always a marked angle at the end of Cu_2 between the claval and distal portions of the posterior margin, whereas in the Auchenorrhyncha the posterior margin is straight. It is very instructive to note that the Lower Permian family Permoscytinidae and a number of the known Copeognatha of the same age show a slight break in the contour of the posterior margin of the forewing at end of Cu_2. From some archaic form possessing this character to a somewhat more marked degree the Heteroptera must have arisen.

Three genera of Prosbolidae are known from the Upper Permian of Australia, and may be distinguished as follows:

1. Tegmina less than 15 mm. long, with main stem of M present 2
   Hindwings more than 15 mm. long, with main stem of M obsolescent .... Genus 10. *Mitchelloneura* Till.
2. Basal cell long and narrow, one-fourth or more of the total length of tegmen .... Genus 8. *Permoglyphis*, n. g.
   Basal cell very short, at most only one-eighth of the total length of tegmen .... Genus 9. *Permodiphthera*, n. g.

Genus 8. PERMOGLYPHIS, n. g. (Text-fig. 19.)

Tegmen: Costa very strongly formed, moderately curved from base to nodus (*n*), where it is markedly bent; apical portion of tegmen evenly rounded. At base of costa is a nearly circular, plate-like swelling (*tg*), probably representing the *tegula* of recent Fulgoroidea. Sc short, weakly formed. Basal cell long and narrow, reaching to beyond one-fourth of the total length of the tegmen. From the nodus, a faint, curved, transverse line divides the tegmen as far as Cu_1 into a somewhat roughened, granulate basal portion and a very smooth distal portion; on this latter all the larger veins are somewhat flattened, giving a double outline in the fossil impression. No strongly marked R_{1a} present, but only a series of pterostigmatic veinlets. Rs arising just basad from the dividing line from nodus, and having a small distal fork. Main stem of M distinct, forking irregularly beyond dividing line. Cu_1 strongly curved convexly to Cu_2, with large apical fork arising on the dividing line. Cu_2 straight, ending almost exactly below level of nodus. Clavus triangular, with marked anal angle; 1A long, gently curved sigmoidally; 2A short, closing the anal angle.

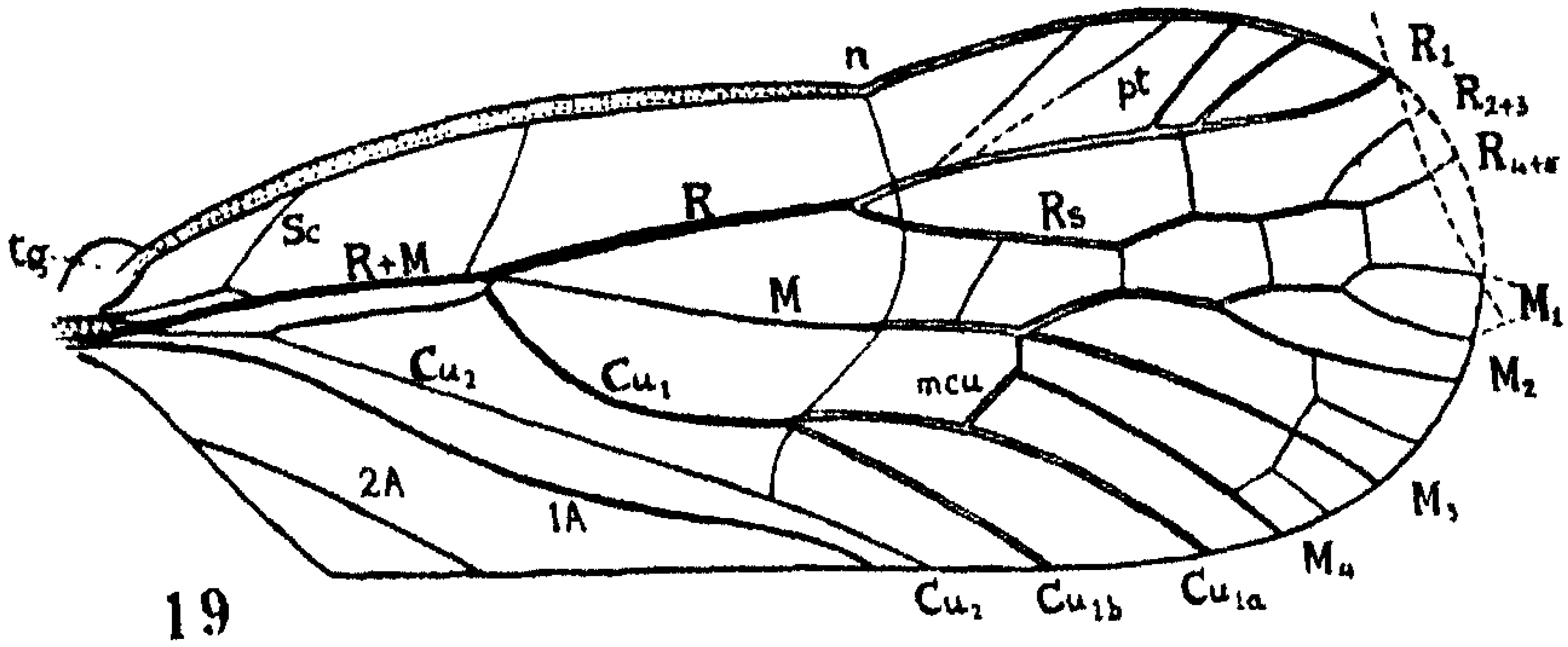
Genotype, *Permoglyphis belmontensis*, n. sp.

Horizon.—Upper Permian of Belmont, N.S.W.

18. PERMOGLYPHIS BELMONTENSIS, n. sp. (Text-fig. 19.)

Tegmen perfect except for a very small portion of apical margin cut off between ends of R_1 and M_1; total length 9·4 mm.; greatest breadth 3·6 mm. A very fine obverse impression, with apex to right, greyish-white on chert of the same colour. The *tegula* (*tg*) is very strongly marked, its outer margin almost semicircular. Sc very short, ending up on R + M before half the length of the basal cell, and sending a faint branch obliquely upwards to costa. A single faint costal veinlet arising from R + M just before end of basal cell. Pterostigmatic veinlets four, arranged in two groups of two each close together; the first two weak, not clearly marked basally (partially obliterated by a local roughness of the rock surface), the second two shorter but well formed. Rs connected with R_1 by a single cross-vein, with M by four cross-veins, and slightly zigzagged at point of origin of each cross-vein except the first. M_{1+2} also slightly zigzagged at the three cross-veins which join it to Rs; M_1 with an extra distal fork. M_3 continues the line of the main stem of M, while what appears to be M_4 arises from it by a short transverse piece at point of origin of M_{1+2} and connected with Cu_{1a} by a strong cross-vein. Between M_1 and M_2, and also between M_3 and M_4 are short interpolated distal veins connected by cross-veins above and below. 1A ending very close to Cu_2.

Type: *Holotype tegmen*, Specimen No. 117 in Mr. Mitchell's Collection; found by him at Belmont, 1925. One of the most perfect specimens yet discovered in these beds.



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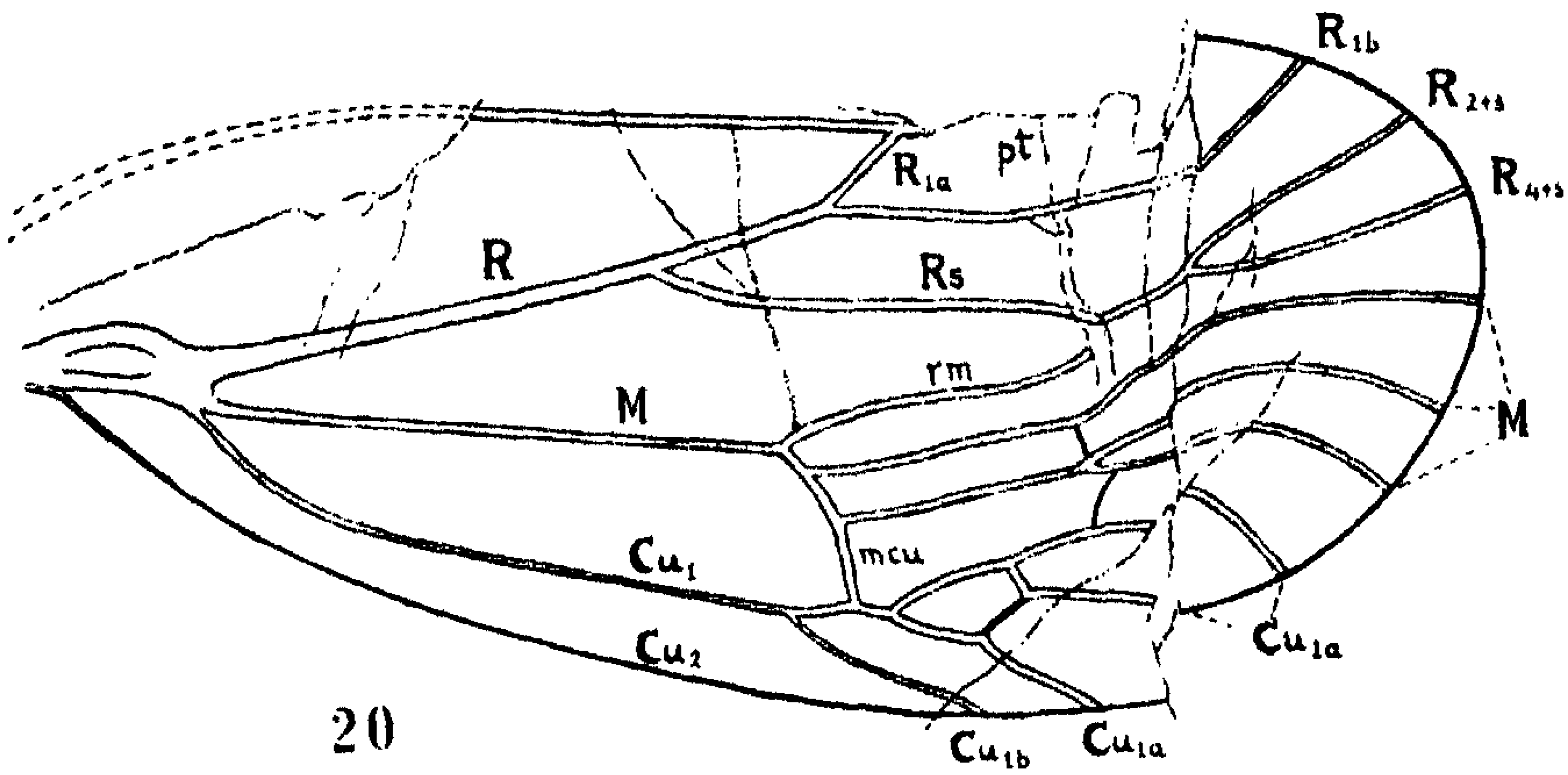

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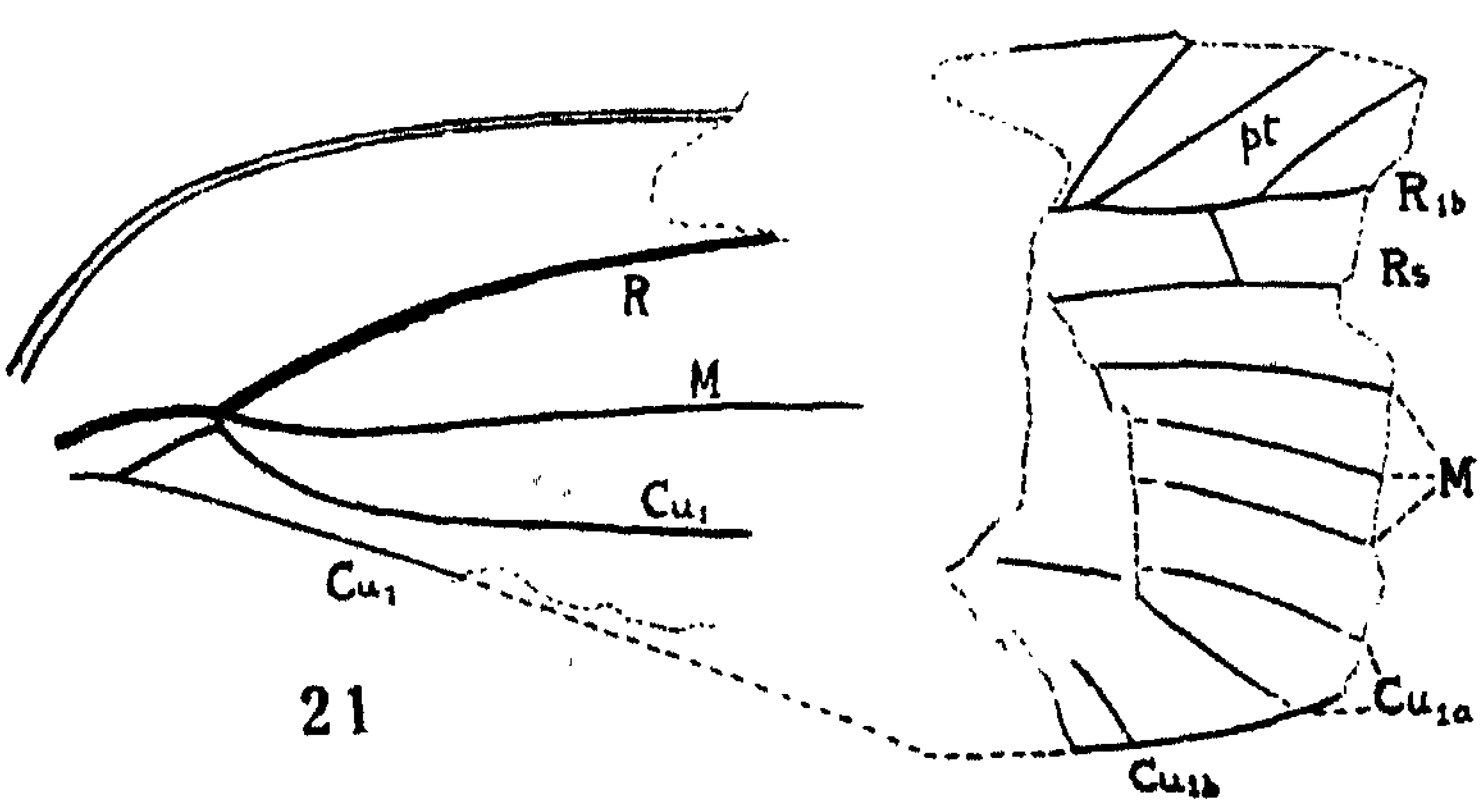

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Text-fig. 19. *Permoglyphis belmontensis*, n.g. et sp., family Prosbolidae; Upper Permian of Belmont. Tegmen. Length 9·4 mm. Lettering as in Text-fig. 1, except *n*, nodus, and *tg*, tegula.

Text-fig. 20. *Permodiphthera robusta*, n.g. et sp., family Prosbolidae; Upper Permian of Belmont. Tegmen. Length 11 mm. Lettering as in Text-fig. 1.

Text-fig. 21. (?) *Permodiphthera dubia*, n. sp., family Prosbolidae; Upper Permian of Belmont. Tegmen. Length 11 mm. Lettering as in Text-fig. 1.

Genus 9. PERMODIPHTHERA, n. g. (Text-figs. 20, 21.)

Tegmen: Costa strongly curved basally, then running fairly straight to R_{1a} or beyond; apex well rounded. Basal cell very small, at most only one-eighth the length of the tegmen. R very stout, straight or slightly curved. Rs distally forked. Main stem of M straight or very gently curved. Main stem of Cu_1 strongly curved downwards so as to come fairly close to Cu_2 not far from basal cell. Both M and Cu_1 with three or four branches distally.

Genotype, *Permodiphthera robusta*, n. sp.

Horizon.—Upper Permian of Belmont, N.S.W.

19. PERMODIPHTHERA ROBUSTA, n. sp. (Text-fig. 20.)

Tegmen 11 mm. long, with distal portion crumpled, representing an actual length of about 13 mm.; greatest breadth 5·2 mm. An obverse impression on grey shale, with apex to right. Clavus and basal portion of costa missing, the latter being cut off by an oblique, irregular break in the rock; a portion of the costa in the pterostigmatic region is also missing, and the main fold in the crumpling of the soft distal portion of the tegmen runs transversely from the end of this break to a point between the ends of the branches of Cu_{1a}, where the margin is badly torn. Division between hard and soft parts is indicated by a transverse dividing line from costa a little before R_{1a} to principal fork of M; below that it is carried on by a strongly bent portion of M, continued by *mcu*. Pterostigmatic area fairly long and deep, without veinlets. Rs connected with M by a long, sigmoidally curved vein which appears to be the specialized *rm*. Owing to the crumpling, the distal branches are not easy to follow out, but M appears to have three branches and Cu_1 four, *mcu* falling on Cu_{1a} before its first branch is given off. Cu_2 somewhat curved.

Type: *Holotype tegmen*, Specimen No. 72 in Mr. Mitchell's collection; found by him at Belmont in 1922.

20. (?) PERMODIPHTHERA DUBIA, n. sp. (Text-fig. 21.)

Tegmen 11 mm. long with apical portion missing, representing a total length of about 13 mm.; greatest breadth about 5 mm. This is an obverse impression with apex to right; clavus and apical portion missing, middle portion obliterated. It differs from *P. robusta*, n. sp., in having R distinctly curved, M slightly curved basally, Cu_2 apparently straight, pterostigmatic veinlets present, also a cross-vein between R_{1b} and Rs; the distal venation is too fragmentary to determine in detail. Probably this species should be placed in a new genus, but it would be better to leave it provisionally in *Permodiphthera* until a better specimen is available.

Type: *Holotype tegmen*, Specimen No. 144 in Mr. Pincombe's Collection; found by him at Belmont, Feb. 24th, 1925.

Genus 10. MITCHELLONEURA Till.

Tillyard, 1922*a*, p. 414, Text-fig. 1.

Genotype, *Mitchelloneura permiana* Till.

Horizon.—Upper Permian, Merewether Beach, Newcastle, N.S.W.

21. MITCHELLONEURA PERMIANA Till.

The fine hindwing on which this species is based has a total length of 17 mm., greatest breadth 7 mm. R immensely strong, with Rs arising about one-fourth

from base. Rs three-branched, the upper branch fusing with R_{1b}. M and Cu_1 both three-branched. A fair number of weak, irregular cross-veins in distal part of wing.

Type: *Holotype hindwing*, in Mr. Mitchell's Collection; found by him in 1921 in a piece of burnt shale from the railway embankment at Merewether Beach.

Besides the above, the very large clavus shown in Text-fig. 22 appears to belong to this family, possibly to the genus *Mitchelloneura*. Total length of fragment 14·5 mm., representing a tegmen which must have been nearly an inch long. The two anal veins are quite separate, as in Scytinopteridae, the anal margin very strong, the anal angle obtusely rounded. This specimen is No. 90 in Mr. Mitchell's Collection, and was found by him at Belmont (date not given).

Division **Sternorrhyncha.**

In this division we place those small fossil tegmina, 6 mm. or less in length, in which the clavus has undergone more or less reduction, with or without loss of one or both anal veins; the great majority of forms have a very narrow clavus without any venation on it at all. The oldest known representative of this Division is *Permopsylla americana* Till. (Text-fig. 23), the only Sternorrhynchous form known from the Lower Permian of Kansas. If this be compared with the Auchenorrhynchous *Permoscytina kansasensis* Till., from the same horizon, a close general resemblance in the venations of the two types will at once be noticed, viz. Sc closely parallel to R, R_1 dividing into a short R_{1a} and a long R_{1b}, with long pterostigmatic area between it and costa, M three-branched, Cu_1 two-branched, cross-veins *rm* and *mcu* present. It is only in the great reduction in length of the tegmen, its broader and more oval form, and in the strong reduction of the clavus with loss of its anal veins, that *Permopsylla* differs from *Permoscytina*.

The Australian Upper Permian beds have yielded the richest Sternorrhynchous fossil fauna yet discovered, some of them being even more archaic than *Permopsylla* itself in that they still retain one or both anal veins on the reduced clavus. Three distinct families may be recognized, according to the following key:

1. R_1 simple 2
   R_1 dividing into a short R_{1a} and a longer R_{1b}, enclosing between them a well-defined pterostigmatic area .... Family *Permopsyllidae*
2. Two anal veins present; Rs simple; M three-branched .... Family *Pincombeidae*
   Anal veins absent; Rs forked; M two-branched .... Family *Lophioneuridae*

Family Pincombeidae.

Sc separate from R, well-developed. R_1 simple. Rs simple. M three-branched. Cu_1 two-branched. Clavus very narrow, with 1A and 2A well developed, close together and parallel.

Genus 11. Pincombea Till.

Tillyard, 1922*b*, p. 282, 281, Text-fig. 2.

Genotype, *Pincombea mirabilis* Till.

Horizon.—Upper Permian of Belmont, N.S.W.

22. Pincombea mirabilis Till.

This beautifully preserved tegmen, only 3 mm. long, was found by Mr. Pincombe at Belmont in 1922, and is in Mr. Mitchell's Collection (Specimen

No. P.2). The costa is somewhat flat, the costal space rather narrow, the apex of the wing at end of R_1, the termen or apical margin very wide. Rs arises a little before half-way. M forks at about middle of wing, the extra fork being on M_{1+2}, with cross-vein *rm* above M_2. Cross-vein *mcu* absent. Cu_1 has a large distal fork. Basal cell barely formed owing to the very weak condition of the basal portions of Cu and Cu_1. Cu_2 runs straight to the posterior margin so as practically to meet Cu_{1a}, and 1A runs so as to end up very close to Cu_2, 2A being a little behind it.

Family Permopsyllidae.

Sc present or absent. R_{1a} present. Rs simple. M with two or three branches. Cu_1 two-branched. Clavus without anal veins, or with one only.

This family contains four genera, viz. *Permopsylla* Till. from the Lower Permian of Kansas, and three new genera from the Upper Permian of Australia. They may be distinguished as follows:

1. Sc present, pterostigmatic area elongated 2
   Sc absent, pterostigmatic area moderate or short 3
2. Sc complete but closely parallel to R_1; pterostigmatic area not strongly chitinized .... (Genus *Permopsylla* Till. Lower Permian of Kansas)
   Sc only separate basally, fused distally with R_1; pterostigmatic area narrowly triangular, strongly chitinized to form a true pterostigma .... Genus 14. *Permothea*, n. g.
3. Rs arising closer to basal cell than to R_{1a} .... Genus 12. *Protopsyllidium*, n. g.
   Rs arising closer to R_{1a} than to basal cell .... Genus 13. *Permopsyllidium*, n. g.

Genus 12. PROTOPSYLLIDIUM, n. g. (Text-fig. 24.)

Tegmen broadly oval. Sc absent. R + M strongly arched. R running practically straight to end of R_{1b} at about two-thirds from base. Pterostigmatic area moderate, about two and a half times as long as the oblique R_{1a}. Rs arising closer to basal cell than to R_{1a}, slightly sigmoidally curved, diverging from R_1. Basal cell well-formed, about one-eighth as long as tegmen. M running straight through middle of tegmen, forking only once, at about two-thirds from base. Cu_1 slightly curved, forking well before middle of tegmen. 1A parallel to Cu_2 for most of its length, diverging slightly apically. No cross-veins except a short basal one connecting Cu_2 with 1A.

Genotype, *Protopsyllidium australe*, n. sp.

Horizon.—Upper Permian of Warner's Bay, N.S.W.

23. PROTOPSYLLIDIUM AUSTRALE, n. sp. (Text-fig. 24.)

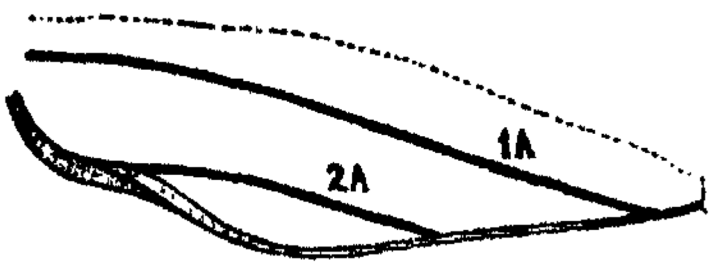
Tegmen with apex missing, 2·8 mm. long, representing a total length of about 3·3 mm.; greatest breadth 1·4 mm. A dark grey impression on a rather dark grey chert; obverse, with apex to right. The apex is cut off transversely by a break in the rock (missing portion restored by dotted lines in Text-fig. 24); there are also shallow breaks along the posterior margin as indicated in Text-fig. 24. The great distance apically between R_{1b} and Rs is remarkable, and is due partly to the shortness of R_1 and partly to the slight sigmoid curvature of Rs. Main stem of M considerably longer than its rather large fork. Main stem of Cu_1 about as long as its fork. Cu_2 ending a little beyond half-way on posterior margin.

Type: *Holotype tegmen*, Specimen No. 140 in Mr. Pincombe's Collection; found by him in a large block of chert brought by him from Warner's Bay in 1924,

and broken open subsequently at his home; this tegmen was discovered on Sept. 12th, 1925, and six other specimens have also been taken from the same block, of which more still remains to be broken up.

Genus 13. PERMOPSYLLIDIUM, n. g. (Text-figs. 25, 26.)

Tegmen broadly oval. Sc absent. R + M scarcely arched at all. R_1 straight to origin of R_{1a}, the latter an oblique branch, straight, but R_{1b} curving strongly upwards distally. Rs much shorter than in previous genus, arising closer to R_{1a} than to basal cell, strongly curved concavely to costa and hence diverging distally from M. Basal cell rather weakly formed posteriorly, about one-sixth the length of



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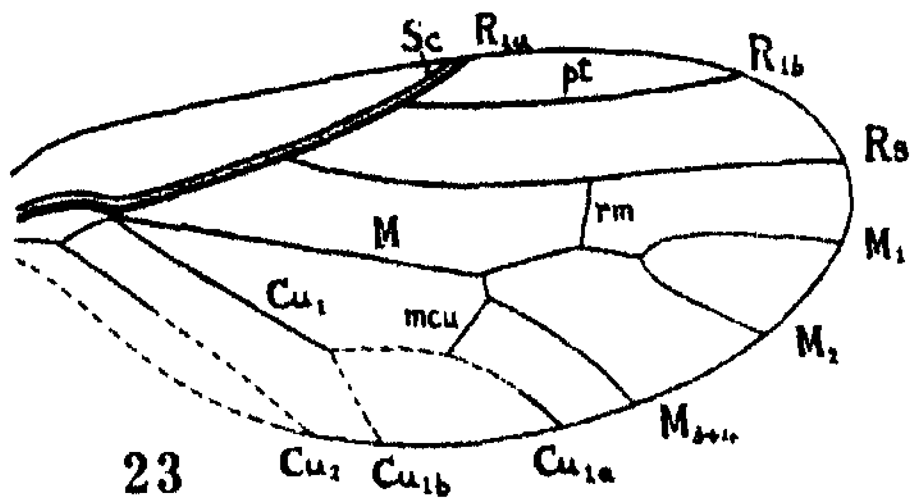

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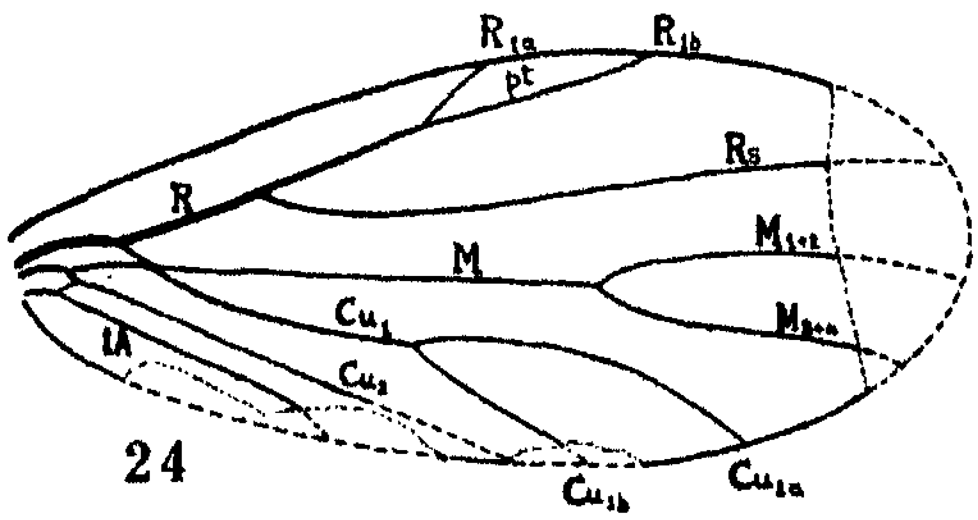

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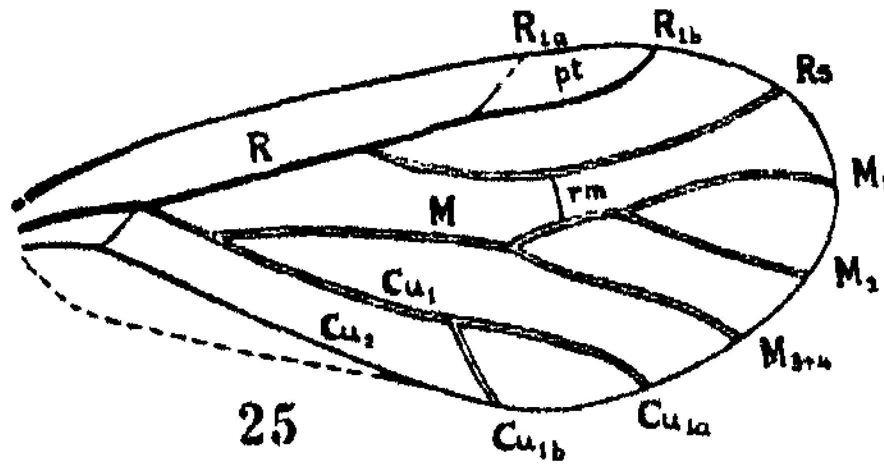

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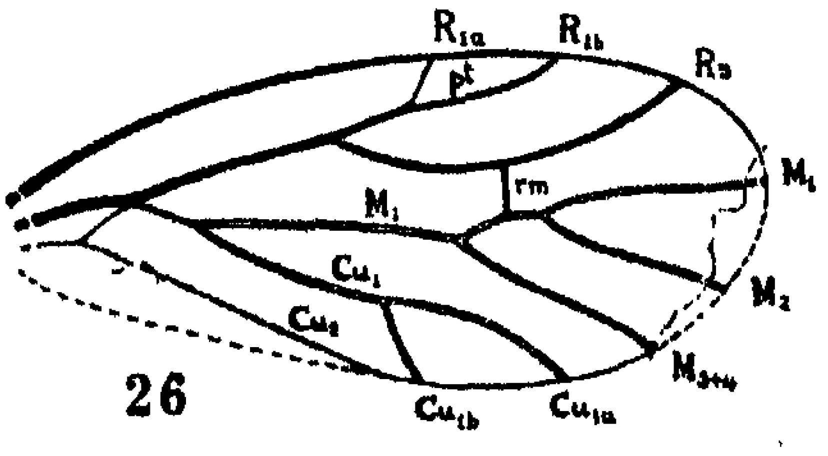

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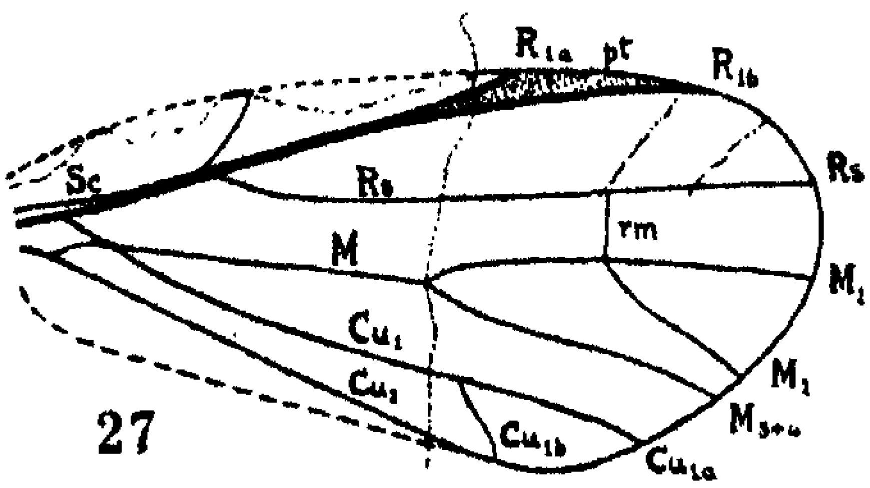

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Text-fig. 22. Clavus of a large, undetermined Homopteron, probably of the family Prosbolidae. Total length of fragment, 14·5 mm. Lettering as in Text-fig. 1.

Text-fig. 23. *Permopsylla americana* Till., family Permopsyllidae; Lower Permian of Kansas, U.S.A. Tegmen. Length 3·2 mm. Lettering as in Text-fig. 1.

Text-fig. 24. *Protopsyllidium australe*, n.g. et sp., family Permopsyllidae; Upper Permian of Warner's Bay. Tegmen. Length of fragment, 2·8 mm. Lettering as in Text-fig. 1.

Text-fig. 25. *Permopsyllidium mitchelli*, n.g. et sp., family Permopsyllidae; Upper Permian of Belmont. Tegmen. Length 3·7 mm. Lettering as in Text-fig. 1.

Text-fig. 26. *Permopsyllidium affine*, n. sp., family Permopsyllidae; Upper Permian of Belmont. Tegmen. Length 3·7 mm. Lettering as in Text-fig. 1.

Text-fig. 27. *Permothea latipennis*, n.g. et sp., family Permopsyllidae; Upper Permian of Warner's Bay. Tegmen. Length 3 mm. Lettering as in Text-fig. 1.

tegmen or a little less. M three-branched, the extra fork being on M_{1+2}. Cross-vein *rm* present, *mcu* absent. Cu_1 forked. Clavus missing, but probably no anal veins present.

Genotype, *Permopsyllidium mitchelli*, n. sp.

Horizon.—Upper Permian of Belmont, N.S.W.

The two closely allied species may be distinguished as follows:

Costa very slightly curved; M_1 curved convexly to Rs right to apex of wing .... *P. mitchelli*, n. sp.

Costa strongly curved; M_1 running straight to apex of wing .... *P. affine*, n. sp.

24. PERMOPSYLLIDIUM MITCHELLI, n. sp. (Text-fig. 25.)

Tegmen (perfect except for loss of clavus) 3·7 mm. long; greatest breadth 1·6 mm. A pale greyish reverse impression, with apex to right, on chert of same colour. R_1 is a strongly impressed vein right to end of R_{1b}, but R_{1a} is weak distally. All the other veins except Cu_2 are slightly flattened, giving a double outline in the fossil. Cross-vein *rm* rather weak, falling on to M_{1+2} about its middle. M_1 curved convexly to Rs right up to apex of wing. Pterostigmatic area about four times as long as wide. The weakly formed free basal piece of Cu_1 bounding the basal cell distally is strongly bent up almost at right angles to the rest of the same vein.

Type: *Holotype tegmen*, Specimen No. 57 in Mr. Mitchell's Collection; found by him at Belmont, March 3rd, 1922.

25. PERMOPSYLLIDIUM AFFINE, n. sp. (Text-fig. 26.)

Tegmen (perfect except for loss of clavus and slight damage to apical border) 3·7 mm. long; greatest breadth 1·7 mm. A pale buff-coloured, obverse impression, with apex to right, strongly tinged with yellow apically, on a whitish chert. Closely similar to the previous species, from which it differs in the more curved costa, the distinctly shorter pterostigmatic region, R_{1a} equally strongly marked from origin to apex, cross-vein *rm* more strongly marked, M_1 slightly curved basally only, then running straight to apex of wing, free basal piece of Cu_1 not quite so strongly bent, Cu_{1a} somewhat more curved.

Type: *Holotype tegmen*, Specimen No. 89 in Mr. Pincombe's Collection; found by him at Belmont, Sept. 20th, 1924.

Genus 14. PERMOTHEA, n. g. (Text-fig. 27.)

Tegmen: Sc present as a free vein basally, then fused with R; a costal veinlet close to origin of Rs may be the free end of Sc. Pterostigmatic area flatly triangular, strongly chitinized so as to form a true pterostigma. Rs arising at about one-third from base, slightly curved basally, then running straight to near apex of tegmen. Cross-vein *rm* present, *mcu* absent. M three-branched. Basal free piece of Cu_1 not much curved, meeting M at about its own length from R, so that basal cell is somewhat diamond-shaped. Cu_1 two-branched.

Genotype, *Permothea latipennis*, n. sp.

Horizon.—Upper Permian of Warner's Bay, N.S.W.

26. PERMOTHEA LATIPENNIS, n. sp. (Text-fig. 27.)

Tegmen 3 mm. long; greatest breadth 1·5 mm. A rather dark greyish impression on a chert of almost as dark a colour; obverse, with apex to right. Clavus missing, costal margin irregularly broken away in places, and a faint crack crossing the wing in the middle transversely. The missing costa is restored

by a dotted line in Text-fig. 27, as is also the clavus. Cross-vein *rm* is faintly marked and falls on to origin of M_3; this latter vein and also Cu_{1b} are posterior branches of M_{1+3} and Cu_1 respectively, the former running without a break to end of M_1, the latter similarly to end of Cu_{1a}. Main stem of M straight, that of Cu_1 slightly curved.

Type: *Holotype tegmen*, Specimen No. 85*a* in Mr. Mitchell's Collection; found by him at Warner's Bay in 1923.

Family Lophioneuridae.

Sc present or absent. R_1 simple, with pterostigma linear or absent. Rs forked distally. M and Cu_1 both with two branches only. Tegmen rather narrowly oval, with clavus reduced to a very narrow area below the somewhat shortened Cu_2.

Genus 15. LOPHIONEURA Till.

Tillyard, 1922*a*, p. 417, 418, Text-fig. 3.

Characters as for the family.

Genotype, *Lophioneura ustulata* Till.

Horizon.—Upper Permian of Merewether Beach and Belmont, N.S.W.

27. LOPHIONEURA USTULATA Till.

A beautifully preserved tegmen, 5·7 mm. long by 1·9 mm. wide, found by Mr. Mitchell in a piece of burnt shale from the railway embankment at Merewether Beach in 1921. Sc is complete, widely separated from R_1, ending up before halfway along costa. R_1 ends in a thickened linear pterostigma which extends beyond the end of R_{2+3} almost to apex of wing (end of R_{4+5}). Cu_1, M and Rs arise separately from R + M near base, one after another, and there is no basal cell present. Apical fork of M large, that of Cu_1 small, with Cu_{1a} much arched, thus being closely similar to the *areola postica* of Copeognatha. Type in Mr. Mitchell's Collection.

28. (?) LOPHIONEURA CONJUNCTA, n. sp.

Tegmen 4·4 mm. long; greatest breadth 1·7 mm. The impression is a reverse, with apex to left, on a medium grey chert; clavus missing, and an oblique crack running across wing. Venation somewhat obscure, the courses of R_1 and Rs in particular not at all clear. Costa exceptionally thick from base up to pterostigmatic area. Differs also from *L. ustulata* Till. in its smaller size, much shorter apical fork of M, presence of *rm*, and in M and Cu_1 coming off by a common stalk from R + M. Only provisionally placed in this genus until a better impression can be obtained, when it will probably be found that a new genus is required for it.

Type: *Holotype tegmen*, Specimen No. 79 in Mr. Pincombe's Collection; found by him at Belmont, August, 1924.

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Cawthron Institute, Nelson, N.Z.

EXPLANATION OF PLATE I.

Fig. 1.—*Orthoscytina mitchelli*, n.g. et sp. Holotype tegmen; length 10 mm. Family Scytinopteridae.

Fig. 2.—*Permoglyphis belmontensis*, n.g. et sp. Holotype tegmen; length 9·4 mm. Family Prosbolidae.

NOTES ON AUSTRALIAN DIPTERA. No. viii.

By J. R. Malloch.
(Communicated by Dr. E. W. Ferguson.)

(Seven Text-figures.)

[Read 31st March, 1926.]

Family **Sapromyzidae**.

In a preceding part of these notes I summarized the characters of this family. I omitted mention, however, of the postvertical bristles. These are convergent in all species of the family known to me, while in Sciomyzidae they are more or less divergent.

I present herein descriptions of some more Australian and Tasmanian species which have been in my hands for some time. While these descriptions are fairly exhaustive, it is quite probable that accessions of fresh material will necessitate careful comparisons of the types with the others to determine specific identities. An intensive study of the whole of the species from this region, with careful comparison of the dissected hypopygia, is the ultimate desideratum and this can best be undertaken by some student favourably situated in Australia where the type specimens will nearly all be available for study.

I hope to be able to present a key for the identification of all the genera known to me in a succeeding paper; meantime, I desire to study further some of the more difficult genera now in my hands.

Genus Depressa novum. (Text-figure 1.)

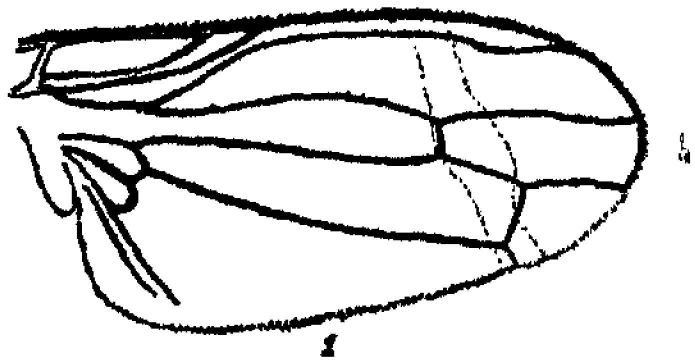
Generic Characters.—Habit similar to that of *Steganopsis* de Meijere. The antennae are short, similar to those of normal species of the genus *Sapromyza*, the basal segment shorter than the second and not hairy below, the third elongate, but not more than twice as long as wide, rounded at apex, and the arista short-haired. Frons flattened, sharp at vertex; postvertical bristles distinct; ocellars minute or absent; both orbital pairs present, backwardly curved; antennae at bases separated by as great a distance as either is from eye, the part between them subangularly produced; face immediately below bases of antennae transversely concave, then quite evenly convex, the labrum large and convex. Both sternopleurals present, the anterior one short; scutellum flattened, quite sharp on margin. Wing as in Text-figure 1, the cross-veins both beyond middle and rather closely placed.

Genotype, *Depressa atrata*, n. sp.

Depressa atrata, n. sp. (Text-figure 1.)

Male.—Head dark fulvous, glossy; ocellar spot black, sides of frons darker than centre and front margin; sides of face silvery; antennae and palpi fulvous. Thorax glossy black, slightly shagreened and less shining on anterior margin of dorsum. Abdomen more pitchy black than thorax, shining. Legs fuscous, apices

of mid and hind tibiae and all of same tarsi, testaceous yellow. Wings fuscous, paler at apices, and with an oblique white preapical band as indicated in Text-figure 1. Halteres black.



Text-figure 1. Wing of *Depressa atrata*, pale band indicated.

Frons about 1·5 times as wide as long; cheek about one-fifth as high as eye; longest hairs on arista about twice as long as its basal diameter. Thorax with three pairs of postsutural dorsocentral bristles and four series of intradorsocentral setulae; prescutellar acrostichals long; scutellum about as long as wide, with four subequal bristles. Fore femur without a preapical anteroventral comb; all tibiae with a preapical dorsal bristle.

Length, 3·5 mm.

Type, Sydney, N.S.W., 19.10.24.

Genus PARALAUXANIA Hendel.

This genus was erected, as a subgenus of *Lauxania*, for the reception of one European species, *albiceps* Fallén. The only character distinguishing it from Hendel's subgenus *Sapromyza* is the presence of but one pair of orbitals. No other characters are mentioned by Hendel and, as I have not a specimen of the genotype before me, I cannot ascertain if other characters are present for distinguishing the genera.

In the material which I have seen from Australia and Tasmania there are several species that have the anterior fronto-orbital bristle absent or reduced to a minute hair, and these species I propose to place in *Paralauxania*. Two of these are described herein.

PARALAUXANIA ELEVATA Fabricius.

Head glossy fulvous yellow, a spot on ocellar region, one where each anterior orbital bristle should be, a mark between each antennal base and eye, one on lower part of each parafacial, apical part of each third antennal segment, apices of palpi, and all of arista, fuscous; parafacials subopaque, white dusted. Thorax fulvous yellow on anterior margin, elsewhere glossy black. Abdomen glossy black; legs concolorous, the basal segment of fore tarsi except its apex, and basal two segments of mid and hind tarsi, testaceous yellow. Wings fulvous yellow, deep black on bases. Calyptrae and their fringes, and the halteres, black.

A very robust large species. Frons about 1·5 times as wide as long, depressed near anterior margin, ocellar bristles much shorter than postverticals; anterior orbital usually absent; the surface with very few microscopic hairs; antennae elongate, third segment tapered apically, more than three times as long as its basal width; arista with very short pubescence; face convex above; eye narrowed below, more than twice as high as cheek; postocular bristles black, not descending

below middle of eye. Thorax with the dorsal setulae quite strong, about six series between the dorsocentrals; of the latter there are two strong prescutellar pairs, and, anterior to these, two or three much weaker postsutural pairs; prescutellar acrostichals strong; sternopleurals two; mesopleural one; scutellum flattened, broader than long, apex subtransverse, apical bristles convergent. Abdomen stout. Fore femur without anteroventral comb; mid femur with a series of bristles on apical half of anterior surface; all tibiae with strong preapical dorsal bristle; mid tibia with two long apical ventral bristles. Inner cross-vein beyond apex of first vein and at middle of discal cell; last section of fourth vein less than 1·5 times as long as preceding section.

Length, 6-6·5 mm.

Two specimens, mounted on same card, Devonport, Tasmania (Lea).

PARALAUXANIA FULVICEPS, n. sp.

Female.—Head bright fulvous yellow, glossy except on the parafacials, which are opaque and white dusted; a black spot on ocellar region; a brown mark below each eye; antennae and palpi not darkened; arista fuscous. Thorax and abdomen coloured as in preceding species. Legs pitchy, coxae and apices of tibiae yellowish, testaceous, tarsi pale, fore pair dark apically. Wings luteous, rather inconspicuously infuscated at bases. Calyptrae and halteres black.

Frons flat, subquadrate; ocellar bristles very much smaller than the postverticals; anterior orbitals not evident in type; surface hairs almost lacking; antennae rather short, third segment not more than twice as long as wide; arista with very short pubescence; cheek less than one-third of the eye-height; postocular bristles much weaker than in preceding species, not descending below middle of eye. Thorax with weaker and less numerous setulae, four series between the dorsocentrals, the latter consisting of three rather strong pairs behind suture; prescutellar acrostichals strong; scutellum convex, quite regularly rounded in outline. Legs as in preceding species, but less strongly bristled, the mid tibia with only one strong apical ventral bristle. Wing much as in preceding species, but the apical section of fourth vein is fully 1·5 times as long as preceding section.

Length, 3·5 mm.

Type, Sydney, N.S.W., 26.12.23.

Genus SAPROMYZA Fallén.

This genus as interpreted herein contains a number of groups, the extremes of which are very well distinguished from each other, but unfortunately there are many intermediate or connecting forms and the difficulties attendant upon the elucidation of the species, numerous though they are with the material on hand, will undoubtedly be much increased, and intensified by the addition of more material. I present in synoptic form the external characters I consider to be of use in the identification of the species available to me. I have not made dissections of the male hypopygia, as in many cases I have but one specimen of a species and desire to leave the type intact, preferring to allow some Australian worker to elucidate these species further on the basis of hypopygial characters, which will, I am confident, prove as distinctive here as in the New World species of the genus.

In attempting to group the related forms I have used in my synopsis characters of chaetotaxy rather than those of colour and markings, and believe that, while in a very few cases (*e.g. immaculipes*) some doubt may arise as to the location of the species in the key, the student may identify the included

species with reasonable certainty. In doubtful cases species should be run through all sections of the key and the specimen compared with the description of the species to which it appears to run. There are, of course, many Australian species yet to be discovered, but I believe it would be detrimental to the progress of the study of these insects to publish only species descriptions and withhold the key so essential to their ready identification.

I have some species in my possession which are not included in the key, either because of their poor condition or because I am uncertain of their exact generic status. The key contains 28 species, 21 of which are considered as new.

Key to species of Sapromyza.

1. Thorax with four pairs of strong dorsocentral bristles, the anterior pair as strong as the one behind it and situated in front of suture 2
   Thorax with at most three pairs of strong dorsocentral bristles, the anterior pair at or distinctly behind the suture 8
2. Wings almost uniformly deep fuscous brown; thorax shining brownish testaceous, sparsely haired, the intradorsocentral setulae in two series, only the prescutellar pair long; arista microscopically pubescent; fore femur without an anteroventral comb, almost bare on that surface; mid femur with a fine apical bristle on posterior side and four or five quite pronounced bristles on apical half of anterior side; mid tibia with one strong apical ventral bristle .... 1. *suffusa*, n. sp.
   Wings hyaline, slightly greyish or yellowish 3
3. Only the posterior two pairs of acrostichals long and strong 4
   Four or more pairs of the acrostichals long and strong 5
4. Arista with its longest hairs about as long as its basal diameter; fore femur with a distinct anteroventral comb on apical half; third antennal segment narrowed just beyond insertion of arista, slightly tapered to apex; abdomen subopaque, brownish or fuscous; mid femur with a series of stout bristles on apical half of anterior surface; mid tibia with two long apical ventral bristles .... *hirtiventris* Malloch
   Arista practically bare; fore femur without an anteroventral comb; third antennal segment hardly longer than wide; abdomen glossy black; mid femur without anterior bristles; mid tibia with only one long strong apical ventral bristle .... 2. *pilifrons*, n. sp.
5. Arista almost bare; head fulvous yellow, the ocellar spot and labrum fuscous, orbits hardly darkened, antennae bright fulvous; thorax black, with slight greenish tinge, the entire surface densely grey dusted; abdomen black, with conspicuous greenish lustre; legs yellow, fore pair except knees, mid and hind femora at bases, and same tibiae and tarsi at apices, black; fore femur without an anteroventral comb; mid tibia with but one long strong apical ventral bristle .... 3. *subaeneiventris*, n. sp.
   Arista with its longest hairs conspicuously longer than its basal diameter, at least as long as half the width of third antennal segment; species not greenish on any part of body; fore femur with an anteroventral comb; mid tibia with two long strong apical ventral bristles 6
6. Arista short haired, the longest hairs not more than half as long as width of third antennal segment; third antennal segment, palpi, apices of femora, of tibiae, and of mid and hind tarsi, and all of fore tarsi, black .... 4. *bicoloripes*, n. sp.
   Arista plumose, the longest hairs more than half as long as width of third antennal segment; antennae yellow, third segment at most brownish; legs not sharply bicoloured, either uniformly yellowish, or the femora infuscated except apically 7
7. Femora infuscated except apically; thorax with four narrow brown interrupted vittae on dorsum, and a broader dark brown one on upper part of pleura; abdomen densely opaque grey dusted, a medianly interrupted chocolate brown fascia on base of each visible tergite from second to fifth, and a brown spot on the incurved lateral part of each tergite from first, the one on fourth tergite connected with the basal fascia .... 5. *variventris*, n. sp.
   Legs unicolorous tawny or testaceous yellow; pleura not vittate, thoracic dorsum very faintly or not at all vittate; abdomen unicolorous or very faintly marked .... *spinigera* Malloch

8. Mesopleura with two long, strong, rather closely placed bristles above middle near hind margin; mid tibia with two long strong apical ventral bristles; antennae entirely black, as long as head, third segment fully three times as long as wide, first and second segments subequal on outer side, the first with one or two microscopic hairs below at apex; face distinctly retreating below (Text-fig. 2); parafacials white dusted, with a velvety black mark between each antenna and eye; thorax tawny yellow, unspotted; wings honey yellow, apices very narrowly and faintly brownish; abdomen glossy black .... 6. *magnicornis*, n. sp.
Mesopleura with but one strong bristle above middle on hind margin, rarely with a setula below it; mid tibia with but one long strong apical ventral bristle 9

9. Thoracic dorsum with the anterior one or two pairs of postsutural dorsocentral bristles much weaker than the posterior pair, almost hair-like, the anterior pair almost invariably well behind the suture; arista pubescent, or almost bare ... 10
Thoracic dorsum with the three pairs of dorsocentrals almost equally long and strong, the anterior pair very close to or at suture; arista variously haired 20

10. Head and antennae black, parafacials slightly yellowish and densely white dusted; arista distinctly pubescent; thorax tawny yellow; abdomen shining black; wings greyish hyaline, unmarked .... *sciomyzina* Schiner
Head not entirely black, at least the face yellow or brownish-yellow 11

11. Frons entirely opaque, the orbital stripes black, forming two complete dark velvety vittae; wings conspicuously spotted with fuscous (Text-fig. 3); thoracic dorsum and pleura conspicuously vittate with black; scutellum flattened and black on disc, yellow on sides .... 7. *magnifica*, n. sp.
Frons not entirely opaque, at least the orbital stripes shining 12

12. Antennae largely or entirely black 13
Antennae entirely yellow 19

13. Femora and tibiae testaceous yellow .... 8. *immaculipes*, n. sp.
Femora and tibiae of one or more pairs of legs marked with black 14

14. Arista quite distinctly pubescent; first wing vein ending before or above inner cross-vein; wings unmarked with dark colour 15
Arista nude or almost so, the pubescence visible only under a very high power lens; or, if the arista is obviously pubescent, the first vein ends well beyond inner cross-vein; frons tawny yellow 16

15. Frons black; occiput tawny yellow; only the fore femora blackened .... 9. *alboatra*, n. sp.
Frons yellowish-brown; occiput with a large black mark on each side of upper half; all femora largely black .... 10. *occipitalis*, n. sp.

16. Wings without dark markings 17
Wings with distinct dark markings 18

17. Face with a black line along sutures between central part and parafacials; abdomen black, yellow at base; humeri with some microscopic fine hairs besides the strong bristle; areas mesad of the humeral angles very sparsely furnished with weak setulæ; fore tarsi with a lanceolate bristle at apex of basal segment on posterior side, which is about as long as width of segment .... 11. *lancifer*, n. sp.
Face entirely tawny yellow; humeri without fine hairs; areas mesad of the humeral angles quite copiously furnished with stiff erect short bristles; fore tarsi with two normal shaped bristles at apex of basal segment on posterior side .... 12. *regalis*, n. sp.

18. Wing with a narrow fuscous cloud extending from base along costa to apex of fourth vein, and another faint brownish cloud over outer cross-vein; thoracic dorsum bivittate with fuscous .... *fuscocostata* Malloch
Wing with the dark markings confined to a fuscous suffusion of the cell between apices of auxiliary and first veins; thorax not vittate ...... 13. *stigmatica*, n. sp.

19. Legs with conspicuous black markings; abdomen largely glossy black; arista almost bare .... 14. *flavimana*, n. sp.
Legs and abdomen testaceous yellow; arista long pubescent, the longest hairs fully as long as its basal diameter .... 15. *parviceps*, n. sp.

20. Arista plumose; a well developed bristle present on thoracic dorsum slightly behind and mesad of the supra-alar bristle; fore femur without an anteroventral comb 21
Arista very indistinctly pubescent; no noticeable bristle behind and mesad of the supra-alar bristle 22

21. Submedian pale brown vittae continued to anterior margin of mesonotum; no conspicuous spots on posterior margin of mesonotum .... *aberrans* Malloch
Submedian pale brown vittae broken near anterior margin of mesonotum; a pair of black spots on posterior margin of mesonotum which appear velvety in some lights and which extend on to base of scutellum .... 16. *maculithorax*, n. sp.

22. Entire insect, including the legs, shining testaceous yellow; fore femur with a distinct preapical anteroventral comb; inner cross-vein of wing proximad of apex of first vein .... 17. *unicolorata*, n. sp.
Insect not entirely testaceous yellow, bicoloured, the legs partly black 23

23. Thoracic dorsum not vittate, densely greyish or brownish dusted 24
Thoracic dorsum conspicuously vittate, densely greyish or brownish dusted 26

24. Thoracic dorsum with a dark dot at base of each hair and bristle .... *punctiseta* Malloch
Thoracic dorsum without dark dots on dorsum 25

25. Face with a dark central vertical stripe; dorsum of thorax brownish dusted .... 18. *aureocapitata*, n. sp.
Face without a dark central stripe; dorsum of thorax grey dusted .... 19. *griseadorsalis*, n. sp.

26. Frons rather densely covered with short black setulose hairs anteriorly; face with a vertical line on each side, and frons with a central line, blackish; thoracic vittae blackish, linear, the lateral pair short and indistinct; costal and second veins and outer cross-vein, and sometimes also third vein, bordered with fuscous .... 20. *fuscolimbata*, n. sp.
Frons practically bare except for the strong bristles; face and frons without fuscous lines as above; thoracic vittae brown, quite broad, and all four entire; veins of wings not bordered with fuscous 27

27. Palpi yellow; fronto-orbital bristles situated on a narrow grey stripe which is separated from the grey margin anteriorly by a narrow stripe of the same golden colour as the interfrontalia; fore femur without an anteroventral comb .... *victoriae* Malloch
Palpi black; fronto-orbital bristles situated on the wide whitish lateral stripes; fore femur with a weak but evident preapical anteroventral comb .... 21. *brunneovittata*, n. sp.

N.B.—To facilitate finding the descriptions of the species in the above key I have numbered them in both key and text omitting only the previously described species in the numbers. Should it fall to me to describe any species subsequent to the appearance of this paper, in all cases reference will be made in the remarks on the affinities of such species to the section of this key in which it finds its closest allies, and ready means for its distinction therefrom will be provided by notes on the distinguishing characters. It is to be hoped that other workers who may describe species will follow this plan also until it is possible to give a complete key to all the Australian species; isolated descriptions without such comparative data are usually detrimental to the progress of the study of the group.

Unfortunately I find it impossible to identify definitely most of the old author's species, those of Macquart and Walker being too briefly described to permit of their identification. However, an examination of the type specimens, if still in existence, will no doubt show whether they are the same species as any of those included in this paper. It appears to me that *carinata* Thomson and *nigriceps* Macquart belong in the same group as *sciomyzina* Schiner, but I cannot definitely identify either. Also *aeneiventris* Macquart and *metallica* Walker are no doubt related to *subaeneiventris* described herein, and *rufifrons* Walker and *pallida* Walker are very similar to *aureocapitata* and *griseadorsalis* included in this paper, but I do not care to decide whether they are the same without an examination of the types of the old species. Without a knowledge of the nature of the thoracic chaetotaxy, etc., it is impossible also to place *fuscicornis* Macquart and *tincta* Walker, both of these species appearing, however, to belong to *Sapromyza*.

It is not probable that *analis* Macquart is a *Sapromyza;* if it is, it does not agree with any species at present known to me. Bergroth's species *barnardi* I cannot place.

1. SAPROMYZA SUFFUSA, n. sp.

Female.—Head brownish testaceous, face, cheeks, and lower half of occiput, paler, the first with whitish dusting, frons slightly shining, more pronouncedly so on orbits and frontal triangle; third antennal segment darker at apex than at base; arista fuscous; palpi testaceous yellow. Thorax shining brownish testaceous, immaculate. Abdomen shining pitchy black. Legs pitchy. Wings fuscous, darker on costal portion. Halteres testaceous brown.

Frons a little broader than long; ocellar bristles as long as postverticals; anterior orbitals a little shorter than posterior pair; third antennal segment about 1·5 times as long as wide; arista with very short pubescence; cheek not as high as width of third antennal segment; eye narrowed below. Thorax with four pairs of strong dorsocentrals (1 + 3), a pair of fine prescutellar acrostichals, and two series of fine intradorsocentral hairs; scutellum slightly flattened, a little elongated, the bristles subequal; anterior sternopleural bristle short. Abdomen elongate, bristles short. Fore femur without an anteroventral comb; hind femur without a preapical anteroventral bristle; all tibiae with strong preapical dorsal bristle; mid tibia with but one apical ventral bristle. Inner cross-vein a little beyond apex of first vein and close to middle of discal cell.

Length, 3·5 mm.

Type, Kosciusko, N.S.W., 27.12.24 (Goldfinch).

2. SAPROMYZA PILIFRONS, n. sp.

Female.—Shining fulvous, the abdomen, except base, glossy black. Wings honey-yellow. Halteres yellow.

Frontal bristles rubbed off in type, but the scars left indicate that they were all of normal strength, including the ocellar pair; frons subquadrate, with numerous short black surface hairs; third antennal segment not much longer than wide; arista almost bare; cheek more than half as high as width of third antennal segment; eye but little narrowed below. Thorax with four pairs of strong dorsocentral bristles (1 + 3), one pair of long prescutellar acrostichals, and about six series of intradorsocentral setulae, the submedian two series longest; scutellum short and convex, bristles equal. Abdomen stout, normal. Fore femur without an anteroventral comb; mid femur without distinct apical anterior bristles; all tibiae with preapical dorsal bristle, on hind pair much the weakest; mid tibia with but one strong apical ventral bristle. Inner cross-vein quite distinctly before apex of first vein and at middle of discal cell.

Length, 6 mm.

Type, Tasmania.

This species, despite the presence of presutural dorsocentrals, appears to be more closely related to the *sciomyzina* group than to the one it is linked with in the key.

3. SAPROMYZA SUBAENEIVENTRIS, n. sp.

Female.—Head orange-yellow, frontal orbits slightly brownish and a little shining, ocellar region fuscous; arista dark; antennae and palpi orange-yellow. Thorax black, slightly shining, and a little greenish, the surface obscured by rather dense greyish dust. Abdomen metallic blue-green, less densely grey dusted

than thorax. Legs dull orange-yellow, fore pair except knees, coxae, bases of femora (broadly), apices of tibiae, and of tarsi of mid and hind legs, black. Wings and halteres luteous.

All frontal bristles distinct, frons a little narrowed in front, as long as wide; arista with very short pubescence; third antennal segment about 1·5 times as long as wide; cheek not as high as width of third antennal segment; eye narrowed below. Thorax with four pairs of strong dorsocentrals (1 + 3), and about five pairs of strong acrostichals (1 + 4); scutellum convex, bristles subequal; anterior sternopleural quite long. Abdomen normal. Fore femur without an anteroventral comb; all tibiae with long preapical dorsal bristle, the one on hind tibia about one-third of the tibial length from apex; anterior bristles on mid femur rather fine; mid tibia with but one long apical ventral bristle. Inner cross-vein a little before apex of first vein and just beyond middle of discal cell, the wing narrow.

Length, 4 mm.

Type, Collaroy, Sydney, N.S.W., 29.1.24.

This species agrees very closely with the description of *aeneiventris* Macq., and also *metallica* Walker, but there are several other species which also do so and, unless an examination and redescription of the types of those species is made, it will be impossible to determine the exact identity of the species.

4. Sapromyza bicoloripes, n. sp.

Female.—Head opaque reddish testaceous, with grey or whitish dusting except on two marks on frons which are shaped like a J, the one on right side reversed, and a spot between each antenna and eye, which are reddish-orange, shading into brown; third antennal segment, arista, and palpi, blackish. Thorax reddish testaceous, quite densely grey pruinescent, dorsum with four rufous vittae, margin of scutellum dark brown. Abdomen slightly shining, brownish testaceous, bases of tergites darker, slightly grey dusted. Legs dark yellowish testaceous, apices of femora and tibiae, nearly all of fore tarsi, and apices of mid and hind tarsi, blackish. Wings yellowish hyaline. Halteres whitish.

All frontal bristles long, the postverticals shorter than the ocellars; frons a little longer than wide; arista with its longest hairs about half as long as width of third antennal segment, the latter fully 1·5 times as long as wide; cheek not as high as width of third antennal segment; palpi slender. Thorax with four pairs of strong dorsocentrals (1 + 3), four pairs of strong acrostichals (1 + 3), and about two series of short hairs each side between the acrostichals and the dorsocentrals; scutellum short, subconvex, bristles equal. Abdomen normal. Fore femur with a fine anteroventral comb; all tibiae with preapical dorsal bristles; mid tibia with two long strong apical ventral bristles. Inner cross-vein of wing slightly before apex of first vein and middle of discal cell.

Length, 5 mm.

Type and paratype, King Island, Tasmania (Lea).

5. Sapromyza variventris, n. sp.

Female.—Head opaque brownish testaceous, the fronto-orbital stripes and triangle more greyish, a brown spot between each antenna and eye, and a fainter transverse mark above mouth; antennae reddish-yellow, apex of third segment brownish; arista brown, paler at base; palpi yellowish. Thorax subopaque, light brownish testaceous, dorsum with six narrow pale brown vittae, only the submedian pair very distinct, the others incomplete; pleura with a broad brown

vitta on upper half and a much fainter, narrower one below it, lower part of sternopleura fuscous; scutellum pale brown on sides. Abdomen densely grey dusted, each tergite except the first visible one with a centrally interrupted blackish fascia on anterior margin, the one on fourth tergite broadest, and a spot on the incurved lateral part of all tergites. Legs dusky testaceous yellow, femora almost entirely fuscous. Wings yellowish hyaline. Halteres testaceous.

Frons subquadrate, with microscopic hairs in front; postvertical bristles of moderate length, but much shorter than the long ocellars; anterior orbitals a little shorter than the posterior pair; third antennal segment about 1·5 times as long as wide; arista with short and long hairs intermixed, the longest about as long as width of third antennal segment; cheek as high as width of third antennal segment; eye slightly narrowed below. Thorax with four pairs of strong dorsocentrals (1 + 3), and a few short setulose hairs on dorsum; anterior sternopleural a little shorter than posterior one; scutellum flattened above, not elongated, the bristles equal. Abdomen with normal armature except on sides of third and fourth visible tergites where the hairs are very fine and erect, denser and shorter on the third. Fore femur with a distinct preapical anteroventral comb; bristles on apical half of anterior surface of mid femur strong; preapical dorsal bristle present on all tibiae, shortest on hind pair; mid tibia with two long strong apical ventral bristles. Inner cross-vein a little beyond apex of first vein and middle of discal cell.

Length, 4 mm.

Type, Narrandera, N.S.W.

A male taken at the same time and place as the above has the abdomen entirely black, with grey dusting, and appears to be different. It agrees very well with the female of *spinigera* Malloch, but may be distinct from both. More material is required to determine this.

6. SAPROMYZA MAGNICORNIS, n. sp. (Text-figure 2.)

Female.—Head fulvous yellow, frons opaque except on the orbital stripes and ocellar region, the latter with a fuscous mark; a velvety brownish-black mark between each antenna and eye; parafacials white dusted, subopaque; centre of face shining, antennae and arista black; palpi black. Thorax shining fulvous yellow, unspotted. Abdomen glossy black. Legs fulvous yellow, entire fore femora, fore tibiae and tarsi except their bases, apices of mid and hind tibiae and of same tarsi, black. Wings honey-yellow, their extreme apical margins becoming brownish. Halteres yellow.

Head in profile as in Text-figure 2; the parafacials with some microscopic hairs on upper part; ocellar bristles lacking; basal antennal segment with a few hairs below; frons subquadrate. Thorax with three pairs of prescutellar dorsocentrals, the anterior pair short, two pairs of prescutellar acrostichals, and four series of intradorsocentral setulae; scutellum convex, with four equal bristles; mesopleura with two strong bristles. Fore femur without an anteroventral comb, the posteroventral bristles strong on apical half only; fore tarsi normal; all tibiae with preapical dorsal bristle; mid tibia with two long strong apical ventral bristles. Inner cross-vein before apex of first vein and a little beyond middle of discal cell.

Length, exclusive of antennae, 8 mm.

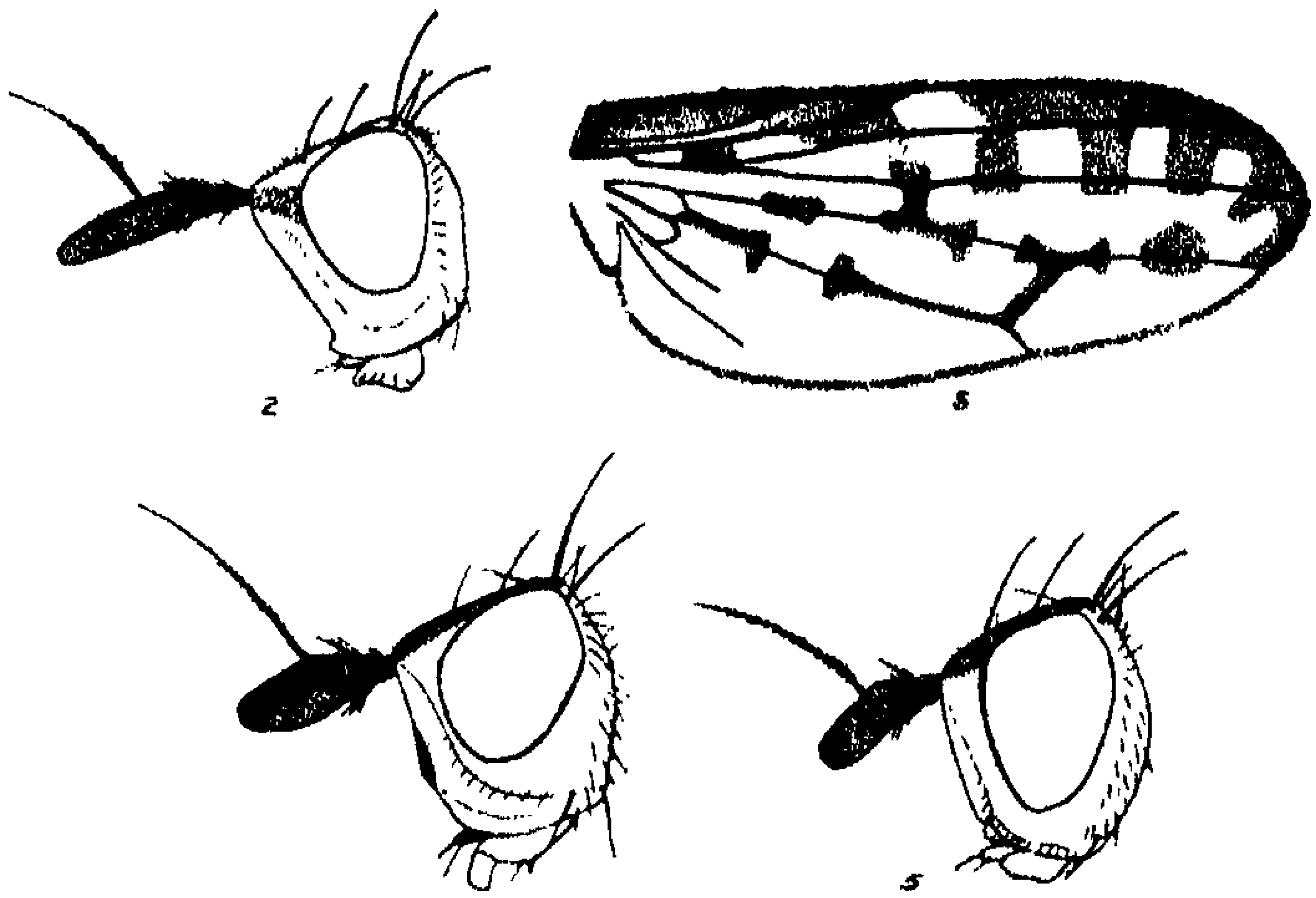
Type, Mt. Arthur, Tasmania, 28.12.1915 (F. M. Littler).

This aberrant species might be placed in a distinct genus because of the presence of fine hairs on under side of basal segment of antenna, and a second

strong mesopleural bristle, but in general habit and in its other structural features it so closely resembles several other species which lack those two features that it appears best to leave it in *Sapromyza*, at least until the Australian species are more thoroughly studied.

7. SAPROMYZA MAGNIFICA, n. sp. (Text-figures 3, 4.)

Male.—Frons opaque orange-yellow, the ocellar spot and a stripe along each series of orbital bristles black, face shining yellow, with a chocolate coloured central vertical stripe, parafacials yellow, not distinctly shining, with white dusting; antennae brown, paler below; palpi yellow, dark at apices. Thorax



Text-figure 2. Head of *Sapromyza magnicornis* from side.
Text-figure 3. Wing of *Sapromyza magnifica*.
Text-figure 4. Head of *Sapromyza magnifica* from side.
Text-figure 5. Head of *Sapromyza alboatra* from side.

shining honey-yellow, with two complete submedian dorsal vittae, a vitta along each pleuronotal suture, the greater part of sternopleura, and disc of scutellum, black. Abdomen black, bases of tergites glossy, apices grey pruinescent and subopaque; hypopygium tawny yellow. Legs honey-yellow, front sides of fore coxae, nearly all of fore femora, apices of mid and hind femora, apices of all tibiae, and apical three or four segments of all tarsi, black. Wings yellowish hyaline, with dark brown markings as in Text-figure 3. Halteres yellow.

Profile of head as in Text-figure 4; frons a little longer than wide, flat; arista nearly bare. Thorax with three or four pairs of postsutural dorsocentrals, the anterior pair, or two pairs, much shorter than the posterior pair, and not close to suture; only two series of intradorsocentral setulae present; scutellum flattened and more elongate than in the two preceding species, almost subtriangular. Hypopygium large and thick, heavily chitinized, recurved below abdomen. Legs as in *magnicornis*, the mid tibia with but one apical ventral bristle.

Length, 6-6·5 mm.

Type and one paratype, Mt. Wellington; one paratype, Hobart, Tasmania (Lea).

8. SAPROMYZA IMMACULIPES, n. sp.

Male.—Head dusky clay-yellow, ocellar region and a mark on upper part of each parafacial brownish; antennae and apices of palpi black; parafacials white dusted. Thorax shining testaceous yellow, with slight greyish dusting, most noticeable on pleura. Abdomen concolorous with thorax, in type largely infuscated on median tergites. Legs testaceous yellow, the apices of tarsi darkened. Wings greyish hyaline. Halteres yellow.

Frons about 1·25 times as long as wide; head in profile similar to that of *alboatra*, but the eyes not so narrow; arista subnude; antennae as in *alboatra*. Thorax with the two posterior pairs of dorsocentrals long, the anterior pair short and closer to suture than usual in this segregate, the intradorsocentral setulae in two or three series; scutellum convex. Legs normal. Inner cross-vein below or very slightly beyond apex of first vein and a little beyond middle of discal cell; first posterior cell slightly widened at apex.

Length, 4·5 mm.

Type, Sydney, N.S.W., 28.6.24.

9. SAPROMYZA ALBOATRA, n. sp. (Text-figure 5.)

Male.—Frons shining brownish-black, face and cheeks opaque yellowish-white, occiput fulvous yellow; antennae, arista, and palpi, black. Thorax shining fulvous yellow, immaculate. Abdomen glossy black, basal two segments yellow. Legs fulvous yellow, fore pair beyond basal third of femora, apices of mid and hind femora and same tarsi, black. Wings yellowish hyaline, more yellowish along costa. Halteres yellow.

Head in profile as in Text-figure 5; frons subquadrate; ocellar bristles of moderate length; postverticals long, well below upper margin of the rounded vertex. Thorax as in preceding species, but there are six series of intradorsocentral setulae present; only one pair of distinct prescutellar acrostichals, and but one strong mesopleural bristle present. Inner cross-vein below or slightly beyond apex of first vein.

Length, 5·5 mm.

Type and paratype, Launceston, Tasmania.

10. SAPROMYZA OCCIPITALIS, n. sp.

Male.—Differs from the preceding species in having the frons brownish-yellow, the face not so noticeably whitish except on sides, the upper half of occiput with a large subtriangular blackish mark on each side which does not extend to eye; thorax more testaceous yellow and with greyish dusting; fore femur entirely, mid and hind pairs largely, blackened.

Structurally the species are very similar, but the thorax has four series of intradorsocentral setulae, and the wings are narrower and less broadly rounded at apices.

Length, 5·5 mm.

Type, Sydney, N.S.W., 6.11.24.

11. SAPROMYZA LANCIFER, n. sp.

Male.—Head fulvous yellow, ocellar spot, antennae, arista, and a line on vertical facial sutures, black; palpi yellowish; frons opaque, orbits shining, the latter and a central vitta paler. Thorax fulvous yellow, shining, immaculate. Abdomen pitchy black, yellowish at base, shining. Legs coloured as thorax, outer

side of fore coxae, all of remainder of fore legs, extreme apices of mid and hind femora, all but bases of same tibiae, and the apices of same tarsi, black or fuscous. Wings yellowish, more intensely so on costa. Halteres fulvous.

Head as in *occipitalis*, the face a little more retreating below. Thorax as in *occipitalis*. Wing rather long and narrow, more pointed than in preceding species, the inner cross-vein below a point about midway between apices of auxiliary and first veins. A striking character in this species is the presence of a lanceolate bristle at apex of basal segment of fore tarsus on its outer or posterior side, the length of the bristle being about equal to the width of the segment. Hypopygium large, forceps stout and curved.

Length, 7 mm.

Type, summit of Mt. Wellington, Tasmania (Lea).

It is possible that the female of this species will lack the lanceolate bristle on fore tarsus.

12. Sapromyza regalis, n. sp.

Female.—Differs in colour from *lancifer* as follows: The thorax and abdomen are dull concolorous fulvous yellow, the black colour of legs is confined to apices of fore femora, fore tibiae except bases, fore tarsi, apices of mid and hind tibiae and of same tarsi.

The thoracic dorsum is furnished with rather dense, short, and quite stout, setulae mesad of each humerus, whereas in *lancifer* there are a few fine setulae present there; the humeri are more prominent than usual and devoid of fine hairs which is not the case in *lancifer;* the bristles at apex of basal segment of fore tarsus on posterior side are normal in shape; and the inner cross-vein is very slightly proximad of apex of first vein.

Length, 7 mm.

Type, King Island, Tasmania (Lea).

13. Sapromyza stigmatica, n. sp.

Female.—Head dark fulvous yellow, ocellar spot blackish; antennae brown; frons shining on orbits and ocellar region; parafacials white dusted. Thorax tawny yellow, shining. Abdomen pitchy, paler at base. Fore coxae in front, all of remainder of fore legs, extreme apices of mid and hind femora, all of same tibiae, entire hind tarsi, and apices of mid tarsi, black. Wings yellowish hyaline, cell between apices of first and auxiliary veins fuscous. Halteres fulvous yellow.

Similar to *lancifer* in structure, etc. The ocellar bristles are fine and short. The inner cross-vein is placed as in preceding species.

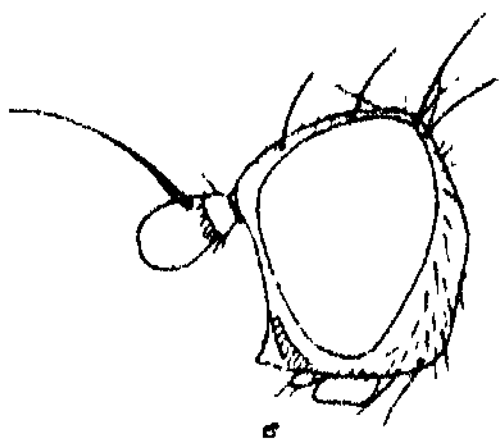
Length, 8 mm.

Type, Warburton, Victoria, 25.1.25 (F. E. Wilson).

14. Sapromyza flavimana, n. sp. (Text-figure 6.)

Female.—Head fulvous yellow, the ocellar region not noticeably darkened. Thorax and base of abdomen concolorous with head, dorsum of mesonotum on hind margin and disc of the scutellum blackened, the colour appearing almost subcutaneous. Abdomen beyond second tergite glossy black. Legs fulvous yellow, practically all of fore femora, and bases and apices of same tibiae, blackened, the bases of tibiae least conspicuously so. Wings honey-yellow, most intensely so along costa. Halteres fulvous yellow.

Head in profile as in Text-figure 6; ocellar bristle short; frons about 1·5 times as long as wide; arista almost bare; cheek almost linear. Thorax with 4-6 series of intradorsocentral setulae, the anterior of the three pairs of dorsocentrals well



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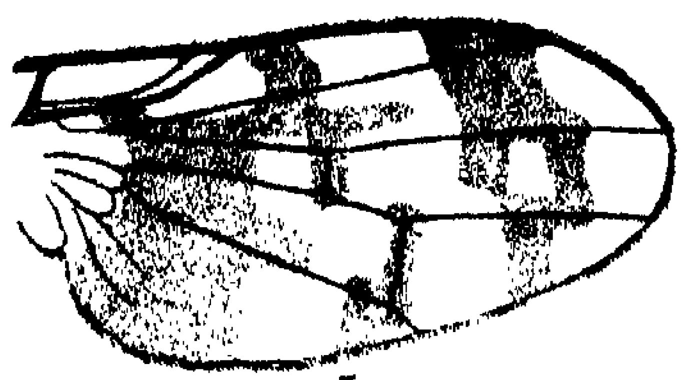

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Text-figure 6. Head of *Sapromyza flavimana* from side.
Text-figure 7. Wing of *Homoneura atrogrisea*.

behind the suture and weak; scutellum convex. Apical segment (7th) of abdomen tube-like. Legs as in preceding species; preapical bristle on hind tibia very much shorter than those on other tibiae. Inner cross-vein almost below apex of first.

Length, 5·5-6 mm.

Type and two paratypes, Hobart, Tasmania (Lea). One paratype without head.

15. Sapromyza parviceps, n. sp.

Female.—Testaceous yellow. Frons shining on orbits, ocellar spot fuscous; antennae and palpi testaceous yellow; arista brownish. Thorax and abdomen shining. Legs testaceous yellow, tips of tarsi hardly darkened. Wings greyish hyaline. Halteres testaceous yellow.

Frons as long as its width at vertex, narrowed in front, surface almost bare; anterior orbitals a little shorter than posterior pair; antennae normal; arista with its longest hairs fully as long as its basal diameter; cheek about one-half as high as width of third antennal segment. Anterior of the three pairs of post-sutural dorsocentrals much shorter than the others, well behind the suture; intradorsocentral setulae in four series, the submedian pairs longest, especially posteriorly, the prescutellar pair conspicuous; scutellum subconvex, bristles subequal; anterior sternopleural short. Abdomen normal. Fore femur with a poorly developed anteroventral comb; anterior bristles on mid femur not very strong; all tibiae with preapical dorsal bristle, that on hind pair short; mid tibia with but one long apical ventral bristle. Inner cross-vein below apex of first vein and at middle of discal cell.

Length, 3 mm.

Type, Sydney, N.S.W., 29.1.25. Four paratypes, Cronulla, N.S.W.

16. Sapromyza maculithorax, n. sp.

Male and female.—Head dull clay-yellow; frons with grey pruinescence on the orbits and ocellar triangle, quite dark brown in middle, pale anteriorly; face broadly fuscous in centre; antennae yellowish, apex of third segment broadly fuscous; palpi fuscous. Thorax clay-coloured, with grey pruinescence, subopaque, dorsum with two brown submedian vittae which do not extend to anterior margin, and terminate in two conspicuous blackish spots on hind margin which extend over base of the scutellum, laterad of these vittae there is a brown spot in front

of suture, and a much larger brown mark behind suture, the latter extending laterad to supra-alar bristle; pleura with a brown mark below humerus and some other brown patches. Abdomen shining, concolorous with thorax, the bases of tergites broadly fuscous. Legs testaceous yellow, femora largely fuscous. Wings greyish hyaline. Halteres yellow.

Frons not longer than wide, all bristles long; arista plumose; cheek not as high as width of third antennal segment. Thorax, legs, and wings as in *aberrans* Malloch.

Length, 4-4·5 mm.

Type, male, allotype, and two paratypes, Sydney, N.S.W.

Most closely related to *aberrans* Malloch, from which it differs in markings of thorax and legs.

17. Sapromyza unicolorata, n. sp.

Male.—Entirely shining testaceous yellow, frontal orbits a little more shining than other parts of frons, ocellar spot not dark.

Frons subquadrate, orbitals all strong, ocellars short but distinct; antennae short; arista with very short pubescence; cheek about as high as width of third antennal segment. Thorax with three pairs of strong postsutural dorsocentrals, one pair of short prescutellar acrostichals, and four series of intradorsocentral setulae; both sternopleurals strong; mesopleura with quite strong hairs, especially below; scutellum flattened above, bristles equal. Abdomen normal. Fore femur with a distinct preapical anteroventral comb; mid femur with some preapical anterior bristles; hind femur with a few short preapical anteroventral bristles; all tibiae with preapical dorsal bristle, that on hind pair shortest; inner cross-vein distinctly beyond apex of first vein and middle of discal cell.

Length, 3·75 mm.

Type, Gisborne, Victoria, 15.11.23 (G. Lyell).

18. Sapromyza aureocapitata, n. sp.

Female.—Head bright orange-yellow, ocellar spot fuscous, orbits greyish yellow dusted both on eye margins and along the lines of bristles, face similarly dusted and with a faint blackish vertical line in middle; antennae and palpi orange. Thorax fuscous, densely brownish-yellow dusted on dorsum, more greyish on pleura. Abdomen coloured as thorax, but slightly shining, the bases of tergites brown, their apices greyish. Legs dull orange, fore femora and tibiae almost entirely, a broad annulus near bases of mid and hind tibiae, apices of same tibiae, apical four segments of fore tarsi and apical two of mid and hind pairs, blackish, the sub-basal annulus on mid tibiae and darkening of mid and hind tarsi least distinct; fore metatarsi testaceous yellow. Wings and halteres yellowish.

Frons a little longer than wide; ocellars smaller than postverticals; both orbitals long; arista subnude; cheek almost linear. Anterior pair of the three postsutural dorsocentrals rather short; intradorsocentral setulae in four series, the central pairs rather long, the two or three posterior pairs conspicuously so; mesopleural hairs very inconspicuous. Abdomen normal. Fore femur without an anteroventral comb; preapical tibial bristle present. Inner cross-vein before apex of first vein and at middle of discal cell.

Length, 4 mm.

Type, Sydney, N.S.W., 6.7.24.

19. SAPROMYZA GRISEADORSALIS, n. sp.

Female.—Differs from the preceding species in having the face without a dark central mark, the dorsum of thorax greyish like the pleura, the mid and hind tibiae without the sub-basal annulus, and the wings greyish hyaline. There are no evident structural differences.

Length, 4 mm.

Type, Sydney, N.S.W., 28.9.24.

20. SAPROMYZA FUSCOLIMBATA, n. sp.

Male and female.—Subopaque clay-coloured, densely grey pruinescent. Frons with a narrow fuscous central stripe connecting with the dark ocellar mark, each side of this stripe the surface is yellowish-brown; face whitish dusted and with a dark line on each side below antennae; a brownish mark between each antenna and eye; antennae and palpi yellowish. Thoracic dorsum with two narrow brown vittae along the lines of dorsocentrals, and sometimes two fainter partial vittae laterad of these, the submedian pair continued over scutellum. Abdomen with a faint dark centrally interrupted fascia on each tergite. Legs clay-yellow, all femora largely, and sometimes the tibiae faintly, grey or fuscous, apices of tarsi slightly dark. Wings greyish hyaline, costa, first, and sometimes second vein, and both cross-veins bordered with fuscous. Halteres testaceous.

Frons about 1·5 times as long as wide, with numerous stiff black setulae anteriorly; ocellars shorter than postverticals; anterior orbital very little in front of middle of frons; orbits not differentiated; frons in profile slightly protruded, the face receding a little below; highest part of cheek about as high as width of third antennal segment, the latter rounded in front and barely longer than wide; arista slender, almost bare. Thorax with three pairs of dorsocentrals, the anterior pair at suture, in one specimen with an additional presutural pair, six series of intradorsocentral setulae, and one pair of moderately long prescutellar acrostichals; scutellum slightly flattened, bristles equal; sternopleurals long. Abdomen stout, the apical bristles on tergites of moderate length. Inner cross-vein a little beyond apex of first vein and middle of discal cell; fore femur without an anteroventral comb; preapical bristle weakest on hind tibia.

Length, 3·5 mm.

Type, male, marked (1) on card, allotype, to left of type on card, and 8 paratypes, the whole mounted, 5 on each of two cards, King Island, Tasmania (Lea). Beach.

Mounted with the specimens are the same number of empty puparia. These are brownish-red in colour and of the typical muscoid form. I leave the description of these to someone who may be able to deal with the immature stages of the family, on which we have practically no information at present even in Europe.

21. SAPROMYZA BRUNNEOVITTATA, n. sp.

Female.—Head opaque yellowish clay-coloured, with whitish dusting; frons orange in centre, more brownish on each side in front, the orbits broad, completely greyish-white; face with a blackish central streak; antennae brownish fuscous, paler at base of third segment; arista fuscous; palpi blackish. Thorax concolorous with head, dorsum with four broad dark brown vittae, the submedian pair tapered at anterior extremities and posteriorly continued over disc of scutellum; pleura with some dark marks. Abdomen more yellowish than thorax, distinctly shining, the bases of tergites brownish. Legs clay-yellow, all of fore

femora, both extremities of other femora, and of all tibiae, and apices of tarsi, black, the bases of tibiae least noticeably so. Wings yellowish hyaline. Halteres whitish.

Frons almost as wide as long; orbits not differentiated except in colour, the anterior orbital bristle much in front of middle of frons; ocellars small; surface hairs very sparse and fine; third antennal segment about 1·5 times as long as wide; arista with very short pubescence; cheek about half as high as width of third antennal segment. Thorax with three pairs of postsutural dorsocentrals, one strong pair of prescutellar acrostichals, and six series of intradorsocentral setulae; scutellum flattened, bristles equal. Abdomen normal. Fore tibia with a preapical anteroventral comb; all tibiae with preapical dorsal bristle. Inner cross-vein almost below apex of first vein and at middle of discal cell.

Length, 4·5 mm.

Type and paratype, Sydney, N.S.W.

Most closely related to *victoriae* Malloch, from which it is readily distinguished by the colour of legs, presence of a weak but evident fore femoral comb, etc.

Genus Homoneura v.d. Wulp.

I have already suggested the possibility of *Sapromyzosoma* Malloch being the same as *Homoneura* in this series of papers, and since that was written have received a specimen of *picea* v.d. Wulp, the genotype of *Homoneura*, from Dr. J. C. de Meijere, an examination of which confirms my supposition. The genus, therefore, will bear the name *Homoneura*, unless *Sapromyzosoma* Lioy should be found to be the same, in which case the name will revert to that form.

There are apparently fewer species of this genus in Australia than there are of *Sapromyza*, if the material forwarded to me is any criterion. I withhold a key to the species of the genus meantime, but hope to be able to present one in the next part of this series should my material enable me to do so. I suspect that *barnardi* Bergroth may be the same as *proximella* Malloch, but there are some difficulties attendant upon the elucidation of the species of this group which cause me to defer making a definite statement upon this point until I make an extensive study of all possible material.

Homoneura atrogrisea, n. sp. (Text-figure 7.)

Female.—Head clay-coloured, interfrontalia yellowish, orbits and frontal triangle grey pruinescent, a black mark between each eye and antenna, face and cheeks white dusted, the former with a broad brown transverse mark on middle, upper half of occiput blackish, lower half testaceous yellow, antennae fuscous, base of the third segment yellowish, palpi fuscous. Thorax fuscous, densely grey dusted, humeri yellowish, mesonotum with anterior margin, three large spots behind suture forming an almost complete fascia, and a mark on middle of hind margin which is connected with the postsutural mark, brownish-black; a brown streak on upper margin of pleura and another along middle, brownish-black; scutellum dark brown, testaceous yellow apically, the surface shining, grey pruinescent. Abdomen dark chocolate brown, with a faint yellow central line and a broader line of same colour on the incurved lateral portion of each tergite. Legs dusky testaceous yellow, femora brown, the mid and hind pairs pale in middle, the same pairs of tibiae brown at bases and apices, fore tibiae faintly dark at apices. Wings marked with fuscous as in Text-figure 7. Halteres yellow.

Frons subquadrate, bristles long and strong, anterior orbitals shorter than the posterior pair and close to anterior margin; antennae normal; arista plumose; cheek not more than half as high as width of third antennal segment; eye narrowed below. Thorax with three pairs of long dorsocentrals, the anterior pair in front of suture, a pair of long prescutellar acrostichals, and six series of intradorsocentral setulae; anterior sternopleural short; scutellum flattened, apex thin, bristles equal. Fore femur with an anteroventral comb; preapical tibial bristle present; mid tibia with one long and one short apical ventral bristle.

Length, 3 mm.

Type, Gordonvale, N.Q., October.

Readily distinguished from any species of the genus by the wing markings.

HOMONEURA APICINEBULA, n. sp.

Testaceous yellow, frontal orbits and triangle, thorax, and abdomen shining. Third antennal segment largely, arista entirely, brownish. Genitalia glossy black. Legs testaceous yellow, the tibiae except bases, and the tarsi mostly, brownish. Wings brownish hyaline, cell between apices of auxiliary and first veins, a cloud over each cross-vein, and one at apex of second vein, dark brown, a much paler brown cloud extending narrowly along costa from apex of second vein to apex of fourth and suffusing apices of third and fourth veins, least distinct on fourth. Halteres yellow.

All frontal bristles long and strong, surface hairs short and inconspicuous; antennae normal; arista very short pubescent; cheek nearly as high as width of third antennal segment. Thorax with three pairs of strong postsutural dorsocentrals, one pair of long prescutellar acrostichals, and about eight series of intradorsocentral setulae; scutellum convex, blunt at apex, bristles equal; anterior sternopleural long. Fore femur with an anteroventral comb; all tibiae with preapical dorsal bristle; mid tibia with two long apical ventral bristles. Inner cross-vein well beyond apex of first vein and at two-fifths from apex of discal cell.

Length, 5 mm.

Type and two paratypes, King Island, Tasmania (Lea). Apparently all males.

Family Clusioididae.

This family is generally referred to as Heteroneuridae, but the genus *Heteroneura* has been sunk as a synonym of another genus and the family name has been changed as above. The name Clusiidae has also been used, the basis for this being the genus *Clusia* instead of *Clusioides*, the latter being the genus which was previously known as *Heteroneura*.

But one species is known to me from Australia, from which region the family has hitherto been unknown. This species belongs to *Heteromeringia* Czerny, a genus well represented in the New World.

The three North American species of the family which I have reared were all found in the larval stages in wood of much decayed trees, or under bark of felled trees. They are extremely sluggish in habit, moving very slowly, are cylindrical in shape, bluntly rounded at both extremities, have no chitinous dark mouth-parts, and the anal spiracles are situated upon two elevated chitinous dark projections which differ in shape in the species I have reared. The family is of no economic importance either in larval or adult stages, the flies frequenting fallen timber upon which they may frequently be taken at rest.

Genus HETEROMERINGIA Czerny.

This genus is distinguished by the following characters: Postverticals present; ocellars small; no cruciate bristles on interfrontalia; each orbit with 3 strong bristles, the anterior one incurved; arista pubescent; mid tibia without a preapical dorsal bristle; cross-veins of wings moderately close together; eyes bare.

HETEROMERINGIA AUSTRALIAE, n. sp.

Male.—Frons fuscous brown, paler in front, the orbits testaceous yellow; face coloured like frons; cheeks testaceous, white dusted above, fuscous below; antennae testaceous; palpi fuscous, pale at bases. Thorax pitchy, the dorsum with sides and two submedian vittae testaceous. Abdomen black. Legs testaceous yellow, fore pair except bases of tibiae, bases of mid coxae and of mid femora, black, apices of hind femora and bases of hind tibiae, fuscous. Wings hyaline, with apices broadly fuscous, the dark colour continued along costa and connecting with a broad median fascia which does not extend to hind margin. Halteres yellowish.

Vibrissae single. Dorsocentrals two pairs. Fore and mid femora with numerous fine ventral bristles.

Female.—Differs from the above in having the frontal orbits dark, face not black centrally, palpi yellow, wing with a cloud near base in addition to the other markings, legs testaceous yellow, only the fore tibiae and fore tarsi black.

Structurally like the male, but the fore tarsi are slightly widened.

Length, 4·5-5 mm.

Type, male, Coramba, 15.2.25; allotype, Sydney, N.S.W., February, 1925.

Despite the colour differences I believe the two specimens are conspecific.

Family Muscidae.

Subfamily ANTHOMYIINAE.

EGLE RADICUM Linnaeus.

This species was described under the genus *Egle* in Part v of this series of papers, page 38, but unfortunately the specific name was accidentally omitted.

Subfamily PHAONIINAE.

Genus RHYNCHOMYDAEA Malloch.

There are two species of this genus recorded from Australia, and a third one is now before me. I append a key for the identification of the three species.

Key to species of Rhynchomydaea.

1. Thorax, abdomen, and antennae, fulvous yellow; legs fulvous yellow, tarsi black .... *australis* Malloch
   Thorax entirely, antennae largely, black 2
2. Blue-black species, the abdomen with bluish or greenish grey dusting; antennae black; femora largely blackened .... *carinata* Stein
   Thorax black, grey dusted on dorsum, the supra-alar margin and pleura golden dusted; abdomen yellowish testaceous, more or less blackened apically, the whole surface quite densely golden pollinose and dark checkered; legs fulvous yellow, only the tarsi infuscated .... *pollinosa*, n. sp.

RHYNCHOMYDAEA POLLINOSA, n. sp.

Male.—Head fulvous below, blackish on frons and occiput, the face and cheeks golden pollinose; third antennal segment black except at base; palpi

fulvous. Thorax faintly quadrivittate on dorsum. Abdomen as described in key. Calyptrae fulvous. Wings hyaline, yellow at bases. Halteres fulvous.

Eyes very sparsely haired; frons linear above, bristled on entire length; carina of face prominent; arista plumose; vibrissal angle quite prominent; facial ridges setulose to well above middle. Thorax as in *carinata*, but the short hairs much stronger; prealar short. Abdomen short ovate. Fore tibia unarmed at middle; mid femur with a rather closely placed series of long bristles from base to beyond middle, the apices of which are curved towards apex of femur, the ventral and posteroventral surfaces with short fine hairs; mid tibia with three posterior bristles; hind femur with a series of long anteroventral bristles, fine at base; hind tibia with one anteroventral and two anterodorsal bristles. Fourth vein of wing not evidently curved forward at apex as in *carinata*, but almost uniformly divergent from third.

Length, 7·5 mm.

Type, Perth, W.A., 15.11.1924 (Nicholson).

Genus Helina R.-D.

Helina leai, n. sp.

Male.—Similar to *hirtibasis* Malloch, to which species it runs in my recently published key to the species of the genus. It differs in colour in having the bases of the wings slightly brownish-yellow, the bases of veins brown, and the calyptrae also yellowish-brown.

Structurally the species are very similar, but in the armature of the legs there are distinctions that clearly indicate they are different species. Both have the fore tibia unarmed at middle, and the mid femur with fine bristles ventrally, longest on posteroventral surface, where in *leai* they are stronger than in *hirtibasis*. The mid tibia has from 3 to 6 posterior bristles in both, but in *hirtibasis* it is normal at base, being furnished with short setulae, whereas in *leai* it is covered with dense microscopic pile, presenting a plush-like appearance, and when viewed from behind and above smooth and brownish on the anterodorsal side. The hind femur in *hirtibasis* has a series of fine bristles on the entire length of anteroventral surface, the apical two or three longer and stronger than the others, and the posteroventral surface has a series of shorter and finer bristles on almost its entire length; *leai* has about eight long strong bristles on apical third of anteroventral surface basad of which series there are only short setulae, and the short posteroventral bristles are confined to apical third. Both species have anterodorsal and anteroventral bristles on hind tibiae. The fourth vein is rather obviously curved forward in *leai*.

Length, 11·5 mm.

Type, Mt. Wellington, Tasmania (Lea).

The inclusion of *leai* in the key above referred to may be accomplished as below:

7a. Mid tibiae normally setulose at base on anterodorsal surface; hind femur with a complete series of anteroventral bristles .... *hirtibasis* Malloch
Mid tibiae densely pilose at base, plush-like anterodorsally; hind femur with strong bristles confined to apical half of anteroventral surface .... *leai*, n. sp.

This species is named in honour of the collector, Mr. A. M. Lea, of the South Australian Museum, formerly Government Entomologist of Tasmania.

REVISION OF THE AUSTRALASIAN SPECIES OF *ANILARA* (FAM. BUPRESTIDAE) AND *HELMIS* (FAM. DRYOPIDAE), WITH NOTES, AND DESCRIPTIONS OF OTHER AUSTRALIAN COLEOPTERA.

By H. J. Carter, B.A., F.E.S.

(Five Text-figures.)

[Read 28th April, 1926.]

Revision of the Australasian Species of Anilara *Thoms. (Fam. Buprestidae).*

The generic name *Anilara* was first used by Deyrolle, without definition, and was attributed to that author in various catalogues, e.g. Gemminger and Harold, 1869, Saunders' Cat. Bup., 1871, Masters' Cat. Aust. Col., 1886. Thomson, however, was the first to publish a short characterization of the genus in 1879, and this has been extended in greater detail by Kerremans (Gen. Insect., 1902). Its nearest affinities are with *Anthaxia*, *Notographus*, *Pseudanilara* and *Neocuris*, consisting as it does of small, inconspicuous insects of flat, oblong form, generally of obscure colour. There is thus considerable confusion of nomenclature.

Anthaxia may be at present excluded from the Australian list by the form of the prosternal process (acutely produced).

Neocuris may be distinguished by (1) flat and excavate head, (2) bisinuate base of pronotum, (3) short elytra.

Pseudanilara has been clearly described by its author, whose concluding paragraph states: "Ce genre diffère du genre *Anilara* par sa tête plus large, la disposition de ses cavités antennaires, son prothorax bisinué à la base, et le dernier segment de l'abdomen ni impressionné ni caréné".

The distinction of *Notographus* from *Anilara* is not so clear, and it is not surprising if one or more of Dr. Obenberger's species of *Notographus*, so inadequately described in *Entomologische Blatter*, 1922, p. 72, should be found identical with species described as *Anthaxia* by Macleay.

In this revision I have considered *Notographus* as distinguished from *Anilara* by (1) antennary cavities surmounted by a feeble oblique carina, (2) pronotum subcordate, in general with strong medial sulcus, and bisinuate base. Thus *Anilara* may be separated from the above allies by the nearly straight base of pronotum.

The species occur on foliage and may be taken by beating. The commonest species in Eastern Australia, *A. (Melobasis) obscura* Macl. can often be taken in considerable numbers by shaking or beating dead eucalyptus boughs. I have specimens taken in company at St. Mary's, near Sydney, that vary in size from 4 to 6½ mm. in length. In the "*Genera Insectorum*" Kerremans recorded 18 species of the genus, excluding Macleay's species which are placed under *Anthaxia*. Of the above 18 species, three were non-Australian; the exceptions being two from Africa and one from Brazil.

The following is the result of my investigations:

Anthaxia cupripennis Chev. (*Silb. Rev. Ent.* 1838). This species is repeated in Masters's Catalogue, although Saunders, in his Catalogue of 1871, notes its synonymy with *Cisseis cupripennis* Guér. Type in Coll. Saunders.

A. (*Anthaxia*) *adelaidae* Hope, published in 1846, is thus the first described *Anilara*.

Mr. Blair has kindly lent me a specimen from the Saunders Collection that has been compared with the type—the latter courteously brought to London by Professor Poulton. It is a short, wide species, with a convex, widely rounded prothorax, of a colour that Macleay called brassy-black, i.e. nearly black with a metallic sheen. Other examples from South Australia are distinctly bronze. Sixteen examples are before me from New South Wales, Victoria, South Australia and Western Australia. Dimensions, 3-4 mm. long.

In 1871 Macleay described amongst the "Insects of Gayndah", *Melobasis obscura*, *Anthaxia obscura*, *Anthaxia cupripes*, *Anthaxia purpureicollis* and *Anthaxia nigra*, which he followed up in 1888 by describing *Anthaxia uniformis* and *A. purpurascens* in the "Insects of King Sound".

I have already pointed out in my Revision of *Melobasis* (*Trans. Ent. Soc. Lond.*, 1923, p. 70) that the first of these is an *Anilara* with numerous synonyms and a wide distribution. The second is an *Anilara* that, requiring a new name, I called *A. macleayi*, but which I now find is *A. viridula* Kerr. The following three, as noted by the author, "differ materially from the typical form", a form that has had the distinction of being described under six different genera—at least as regards *A. cupripes*. It is possible that all three are but different forms of the same species. Allowing for a slight doubt on this point they may be for the present considered as two species, A and B, with the following synonymy:

A. *Pseudanilara* (*Anthaxia*) *cupripes* Macl. = *Melanophila* (*Melobasis*) *laticeps* Kerr. = *M. australasiae* Kerr. = *Neocuris dilaticollis* Blkb. = *Neotorresita achardi* Obenb.

B. *Pseudanilara* (*Anthaxia*) *purpureicollis* Macl. = *Anthaxia nigra* Macl. var. = *Pseudanilara roberti* Théry.

When I published my note on A in the "Revision of *Melobasis*" I had not seen Mons. Théry's type of *Pseudanilara*, and, having little knowledge of the genus *Melanophila*, followed Kerremans' nomenclature. Lately, however, Mons. Théry has very courteously sent me his types of *Anilara* and *Pseudanilara*, together with examples of *Melanophila* from Europe and America. Comparing the type of *P. roberti* Théry with Macleay's two species (B *supra*) I find the darker colour of *nigra* to be the sole distinction between them.

Dr. Obenberger's excellent figure, together with his detailed description, leaves no doubt as to the identity of *Neotorresita achardi* with A, while he gives six characters in which the genus differs from *Melanophila* (*Sbornik Entom.*, 1924, p. 19). These certainly remove this insect from the palaearctic genus to which Kerremans referred it.

Anthaxia uniformis Macl. seems to be a moderately common species in Western Australia. Thirteen examples are before me that I have compared with the type. According to my definition above it is a *Notographus*; and is probably identical with the insect so laconically described by Obenberger as *N. thomsoni*. My examples vary considerably in size (though otherwise alike) from 6 to 3½ mm. long. They are of the colour given by Macleay as "brassy-brown sub-nitid", old spirit specimens losing their gloss. As with other western insects, I find "Sea Lake", Victoria (Goudie), Murray River, S.A. (Zietz) and Port Darwin (G. F. Hill)

amongst the labels, while the western examples range from Albany to King's Sound. *A. purpurascens* Macl. is a true *Anilara*, not happily named, since the colour of the type is a clear, brassy bronze without a trace of purple; the pronotum is more convex than usual, the sides nearly straight in the middle, lightly narrowed in front and behind, its disc (also head) closely and rather strongly punctate; neither pronotum nor forehead sulcate. Three examples have been compared with the type, two from Western Australia, the third from Barossa, South Australia, showing a slight variation of form.

In 1879 Thomson defined the genus and described two species. *A. platessa* Thoms., so far as it is possible to determine from its brief description, is probably the very common species *A. (Melobasis) obscura* Macl. I find Thomson's name attached to specimens on some traditional authority. The locality specified by Thomson is "New South Wales. Adelaide" and since, amongst the sixty-six specimens before me, I find examples labelled Gayndah (Q'land), N. S. Wales (many districts), Victoria and South Australia, the author's vague geography may be taken literally. *A. deyrollci* Thoms. is impossible to determine from description. Its colour, dimensions and locality suggest its identity with *A. adelaidae* Hope or *A. planifrons* Blkb. *A. deyrollci* Kerr. (*nec* Thoms.), of which two examples have been sent me, is clearly *A. obscura* Macl.

In 1887 Blackburn described *A. planifrons*, and four years later added *angusta, laeta, subcostata* and *soror*. *A. planifrons* Blkb., of which two cotypes are before me (from Port Lincoln and Moonta respectively), is a near ally of *A. adelaidae* Hope, from which it differs in (generally) smaller size and the absence of the frontal sulcus. I consider it distinct, though I have three examples of *adelaidae* as small as *planifrons*. *A. soror* Blkb., of which I have examined the type, is merely a large ♀ of *A. obscura* Macl. *A. laeta* Blkb. is another close ally of *adelaidae* of which two examples from South Australia (Macleay Mus.) are before me. I find the special characters noted by the author, including the "abdominal carinules", and consider it a valid species. A minute frontal sulcus is visible.

A. angusta Blkb.—Five examples are so labelled in the National Museum, Melbourne, of which one with Mr. French's label is the presumed type. Twenty-one other examples are before me, chiefly from Victoria, but others from Southern New South Wales (Moruya) and South Australia. This species is somewhat like *A. obscura* Macl. so far as its upper surface is concerned, but generally narrower, with the prothorax less wide in the middle and more evidently narrowed behind. Its clear distinction from Macleay's species lies in the structure of the under surface, lucidly described by Théry under *A. cyphogastra* as having a "saillie intercoxale du premier segment abdominal portant une plaque noir bombée, mate, lisse, parfaitement delimitée dans son pourtour et tranchant par sa couleur avec les parties avoisinantes". Blackburn merely notes the hinder segments as "almost laevigate". This character ("plaque noir") also appears in *A. longicollis* Théry, though unnoted in the description, and (*fide* Mr. K. G. Blair) in *A. cuprescens* Kerr., of which the author's words "pronotum relativement plus long, les côtés . . . non arrondis mais subanguleux" apply to some examples more strongly than to others.

I consider the following synonymy established: *A. angusta* Blkb. = *A. cuprescens* Kerr. = *A. cyphogastra* Théry.

A. subcostata Blkb. is a widely ovate species, generally with an oblique subcostate impression extending from the shoulder, and a short subobsolete costa between this and the suture; but in some examples both are rather obscure.

Mr. A. H. Elston has kindly compared examples with the type for me. It is a distinct species that I have seen only from South Australia. This leaves four of Blackburn's species as valid.

In 1898 Kerremans described six species, and two more in 1902, without any comparison with previously described species—except in one instance, in which his note on *A. sulcicollis* "a peu près de la taille de *An. Adelaidina* Hope" (*sic*) is inaccurate in nomenclature and wide of the mark as a diagnosis (if intended for *A. adelaidae* Hope).

I since learn from Mr. Blair that a species which I determine as *Notographus yorkensis* Obenb. has been labelled with a MSS. name by Deyrolle, and also as *A. adelaidina* Hope for specimens in the British Museum, and Kerremans may be referring to this. I cannot find that this latter species has been named previous to Dr. Obenberger's tabular précis of his *Notographus*, but it is, I consider, a true *Notographus*, differing from *A. sulcicollis* Kerr. in having the eyes more closely converging towards the vertex, a strongly cordiform prothorax, wider shoulder outline, and a flatter and more uneven elytral surface. It is a common Queensland insect, taken in some quantity by Messrs. Illidge and Hacker at Tambourine Mountain and the National Park, as well as from North Queensland. Thirty examples are before me. Of *A. sulcicollis* Kerr. I have examined three examples. One, compared with type by Mr. Blair, is from the Richmond River, N. S. Wales, the other two are from Queensland. The metallic patch, near apex of elytra, on an otherwise velvet-like surface, is characteristic.

A. sulcipennis Kerr.—An example from the British Museum labelled Rockhampton, and with Kerremans' type* label is before me, also three examples from the Macleay Museum labelled N.S.W. and Rope's Creek respectively. The base of the pronotum is very feebly sinuate and the elytral apices are more sharply rounded than usual. It is a valid species and I think a true *Anilara*.

A. nigrita Kerr., from a specimen sent by Mr. Blair, is very near the *cuprescens-angusta* species, but is without the abdominal "plaque noir". As I find this to be a specific, not merely a sexual character, *nigrita* for the present must be considered as valid.

A. uniformis Kerr.—An example before me bears Kerremans' type label, and is a little puzzling. It is without the "plaque noir"; the form is very much that of *A. australis* Théry (from Gayndah) with less widely rounded pronotum than is commonly seen in *A. obscura* Macl., but more so than in *A. anthaxoides* Théry which, moreover, is of different colour and surface sculpture. I find an example taken by Mr. Lea at Gayndah exactly corresponds with this, while the gradations of form from this to the more typical *obscura* are to be seen in the long series before me, the colour of which is often dark in old examples. I cannot do otherwise than consider (1) that *A. uniformis* Kerr. = *A. australis* Théry and (2) that both are probably varieties of *A. obscura* Macl. *A. viridula* Kerr. = *Anthaxia obscura* Macl. so that the name *A. macleayi* suggested by me (*Trans. Ent. Soc. Lond.*, 1923, p. 70) is redundant and Kerremans' name now stands. A specimen compared with type of *viridula* has been sent me. The locality, Tasmania, is probably a mistake. I have not seen an *Anilara* from Tasmania in any Australian collection. *A. macleayi* is only known from Queensland and northern New South Wales.

* Kerremans labelled all the specimens of his type series as "type", so that, in many cases, no one example is specially indicated as such.

A. tasmanica Kerr. = *A. sulcicollis* Kerr., so far as I can judge from description, together with Mr. Blair's note, "very close" (to *sulcicollis* K.) "but does not appear to have the shiny sutural patch, though our unique specimen is very dirty—head with similar antennal cavities and the eyes more approximate above than in most". Locality again doubtful.

A. convexa Kerr.—I have only an outline drawing of this which, together with the description, seems to show a valid species distinguished by the combination of black colour, suboval form and the pronotum widest at base. Thus of the eight described by Kerremans, I consider four as valid. There remain only the seven species described in 1910 by Théry, together with his *Pseudanilara*. I have to thank this entomologist for his great courtesy in sending me his types for examination as well as for his helpful correspondence. To entrust his types in the long oversea journey to me was an act inspired by the true scientific spirit—the desire for accurate knowledge. Four of these are certainly valid. *A. anthaxoides* Théry is readily distinguished by its bright violet colour, minute surface sculpture and the prothorax widest at base, arcuately narrowed to the front, the prosternum more convex than in *obscura* Macl., the punctures of the underside coarser and more distant. Twelve examples are before me from New South Wales, Victoria, South Australia (Brit. Mus.), Western Australia (A. M. Lea and W. D. Dodd).

A. longicollis Théry is rather close to *angusta* Blkb. Both have the "plaque noir", but in *angusta* this is quite laevigate and extends the full length of the first segment, while in *longicollis* I can make out some fine punctures thereon, and it does not quite reach the margin of the first segment. The longer prothorax, with its sides evenly and lightly widened, widest at middle, is its chief distinction. Twenty-three examples have been examined from New South Wales, Victoria, South Australia (Ooldea, A. M. Lea), but the majority come from Western Australia where it is common.

A. antiqua Théry is a very distinct species from Townsville (Q.) having a nearly trapezoidal pronotum with straight sides, very acute posterior angles, the elytra oval, wider than prothorax. The type is the only specimen I have seen.

A. acutipennis Théry, if correctly localized, is the third Buprestid known from New Zealand, except for the very doubtful records of Kerremans. It is described from a single damaged specimen "en assez mauvais état". I think its locality requires confirmation.

A. deplanata Théry is quite a typical *A. obscura* Macl. and *A. australis* Théry is (*vide supra*) probably a variety of that species.

A. cyphogastra Théry (*vide supra*).—Dr. Obenberger (*Zeitsch. f. wiss. Insektenbiologie*, 1917, p. 33) has described one species, *A. hoscheki*, from the Aru Islands from a unique specimen in a private collection. This is said to be 9·5 mm. long and is larger than and clearly distinct from any of the Australian species.

The foregoing notes thus record sixteen valid species, including the single *acutipennis* Théry from New Zealand but excluding *Notographus* (*Anthaxia*) *uniformis* Macl. = ? *N. thomsoni* Obenb. The following are new.

Anilara olivia, n. sp.

Oblong, rather wide and convex, subnitid olive-green throughout, the sides of pronotum and apical declivity of elytra brighter in colour than the rest, but without defined metallic area.

Head moderately convex, except for a feeble depression on anterior part of forehead, sparsely pilose, minutely and densely punctate; eyes large, not prominent, inner margin lightly converging behind, the interspace being about one-third of total width. *Prothorax* arcuate-emarginate at apex, anterior angles (seen from above) acute; base feebly bisinuate; base wider than apex (about 4: 3); widest behind middle, thence arcuately converging in front and sinuately narrowed behind, posterior angles sharply rectangular; medial channel very lightly impressed, a large shallow depression on each lobe near base; disc alveolate-punctate, the punctures fine in middle, growing larger laterally. *Scutellum* very small, circular. *Elytra* of same width as prothorax at base, more convex than usual; the basal margin emphasized by a transverse sulcus immediately behind it, apices separately rounded and finely serrulate; surface alveolate-punctate, with slight signs of transverse strioles on basal half. *Prosternum* convex, with wide obtuse process at apex, metasternum deeply sulcate, sparsely pilose; sternal area finely and densely punctate, abdomen with larger, shallower punctures. *Dimensions*, 6·5-7 × 3 mm.

Habitat.—Queensland: Johnstone River (H. W. Brown), in South Australian Museum.

Four examples examined show a species that could be confused only with *A. macleayi* Cart., but is really very different. The following comparison will make this clear:

olivia.	*macleayi.*
Size.—6·5-7 mm. long.	4·5 mm. long.
Colour.—Almost concolorous.	Head and sides of pronotum bright green, elytra with sub-circular metallic area.
Pronotum.—Widest before middle, strongly sulcate.	Widest behind middle, very lightly sulcate.

The sculpture of *olivia* is stronger and more clearly defined, while in form it is more robust and convex.

Type in South Australian Museum.

ANILARA AERARIA, n. sp.

Subcylindric, nitid brassy-bronze above, dark bronze beneath.

Head with a finely impressed sulcus between eyes, these rather widely separated, their inner margins parallel, minutely and closely punctate. *Prothorax*: Apex and base nearly straight, sides rather widely rounded, widest in front of middle, all angles rather wide, the posterior subrectangular; disc regularly and very finely punctate, with some tendency to transverse striolation. *Scutellum* triangular with rounded sides. *Elytra* as wide as prothorax at base, sides parallel for the greater part, with two subcarinate impressions, the first oblique from the shoulders to near apical declivity, the second near sides, forming a pseudo-margin, apical margins minutely serrulate. Beneath finely punctate, prosternal process widely triangular at apex, first two apical segments soldered, the suture scarcely visible. *Dimensions*, 4·5 × 1·8-2 mm.

Habitat.—Western Australia: Geraldton and Mullewa (W. D. Dodd), in South Australian Museum.

Two examples (the sexes) examined. The species is nearest *A. purpurascens* Macl. in colour but differs as follows:

aeraria.	*purpurascens.*
More convex and parallel.	Flatter and more oval.
Head finely sulcate on vertex.	Widely sulcate on front half only.
Sculpture finer.	Coarser.
Pronotum—Sides well rounded, widest before middle.	Sides feebly widened, widest near base.
Elytra with two well marked carinulae.	With slight humeral keel.

Type and paratype in South Australian Museum.

(*N.B.*—On removing the specimens from the cards by immersion in hot water I find that the brassy sheen has been unfortunately changed to a darker bronze.—H.J.C.)

Table of Australasian Species of Anilara.

1.	Colour obscure bronze	2
	Colour black	11
	Colour nitid brassy-bronze	14
	Colour green or largely so	15
2.	Elytra with subcostate impressions	*subcostata* Blkb.
	Elytra without such	3
3.	Widely ovate, pronotum convex, its sides widely rounded	4
	Elongate oblong, pronotum not as above	5
4.	Vertex of head with medial sulcus	*adelaidae* Hope
	Vertex of head without medial sulcus	6
5.	Abdomen bearing a convex black plate between coxae	7
	Abdomen without such plate	8
6.	Colour purple-bronze, abdomen strongly carinulate	*laeta* Blkb.
	Colour dark bronze, abdomen not as above	*planifrons* Blkb.
7.	Pronotum longer, widest in front of middle	*longicollis* Théry
	Pronotum shorter, widest at middle	*augusta* Blkb.
8.	Sides of pronotum nearly straight	*antiqua* Théry
	Sides of pronotum rounded	9
9.	Pronotum widest at base	*anthaxoides* Théry
	Pronotum widest at middle	10
10.	Eyes converging behind, elytra with metallic spot on suture	*sulcicollis* Kerr.
	Eyes parallel, elytra without metallic spot	*obscura* Macl.
11.	Elytra dentate at apex	*acutipennis* Théry
	Elytra rounded at apex	12
12.	Elytra having sinuous sulci	*sulcipennis* Kerr.
	Elytra not sulcate	13
13.	Pronotum widest at middle	*nigrita* Kerr.
	Pronotum widest at base	*convexa* Kerr.
14.	Form subcylindric, each elytron with two carinules	*aeraria*, n. sp.
	Form oval and depressed, elytra with short humeral carinule	*purpurascens* Macl.
15.	Form flat, elytra with black metallic patch	*viridula* Kerr.
	Form convex, elytra without such patch	*olivia*, n. sp.

Synonymy.

A. (Anthaxia) adelaidae Hope = ? *deyrollei* Hope.

A. (Melobasis) obscura Macl. = *platessa* Thoms. = *soror* Blkb. = *uniformis* Kerr. = *deyrollei* Kerr. (*nec* Hope) = *deplanata* Théry = ? *australis* Théry.

**A. (Anthaxia) obscura* Macl. = *viridula* Kerr. = (nom. nov.) *macleayi* Cart.

A. angusta Blkb. = *cuprescens* Kerr. = *cyphogastra* Théry.

A. sulcicollis Kerr. = ? *tasmanica* Kerr.

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* Since I now find that *viridula* Kerr. is the same insect as Macleay's *Anthaxia obscura*, my suggested name *macleayi* should be sunk as redundant, and the species known as *A. viridula* Kerr.

Maoriella novae-zeelandiae Obenb. = *Neocuris (Buprestis) eremita* White.

Dr. Obenberger (*Sbornik entom. Mus. Praze*, 1924, p. 20) has erected a new genus and gives a new specific name to the well known New Zealand species which, described as *Buprestis eremita*, was placed by Kerremans (*Gen. Ins.*) under *Neocuris*.

Lately, at the request of Dr. R. J. Tillyard, I have examined several specimens of this insect and find that its nearest affinities are with *Neocuris* and *Pseudanilara*, the elytra not quite covering the apex of abdomen and the structure of the antennae incline to the former, while the general facies is very near the latter genus. It would seem out of place in the group "Mastogenini sensu Kerremans".

Théry has recently (*Mem. Ent. Soc. Belg.*, 1910) added a third member, *Anilara acutipennis*, to the scanty Buprestid population of New Zealand. Since, however, this is represented only by a single example "en assez mauvais état", I think his locality requires confirmation by the discovery of further material.

Stigmodera mastersi Macl. = *S. hoblerae* Cart. The latter name must disappear. I find that I misdetermined this species.

Chrysobothris cupriventris Thoms. = *C. regina* Kerr. Mons. Théry writes to me that, having seen the type of Kerremans' species, he identifies it as Thomson's species from Brazil—an erroneous label no doubt caused this.

Stigmodera bella Saund. var. *dixoni*, n. var.—I have received from Mr. J. Dixon, of Melbourne, a variety of *S. bella* Saund. that deserves a name, since it appears to be well distributed and of more or less constant pattern. The usual wide dark basal fascia is replaced by a narrow, *post-basal* fascia shaped like the head of a wide pick-axe, the short handle of which extends over the scutellum, the points of the "pick" not extending to the sides, leaving a yellow area behind the narrow dark basal margin. There is also an example in the Macleay Museum, labelled "Brisbane", and Mr. Deuquet has sent me one from Wardell (N.S.W.) in which the dark post-basal area is wider and extends to the sides.

Chalcophora (*Chrysodema*) *subfasciata* Cart.—Mons. Théry also points out that this species is a true *Chalcophora*, a genus now to be added to the Australian list.

PSEUDANILARA DUBIA, n. sp.

Narrowly oblong, uniformly obscure bronze above, subnitid beneath.

Head rather wide, eyes widely separated, the inner margins parallel, the outer margins prominently convex, surface as also that of pronotum and elytra finely alveolate-punctate, without sulcus or impressions. *Prothorax*: Apex and base bisinuate and almost equally wide, anterior angles acutely produced, sides strongly and evenly rounded, widest at middle, lightly sinuate before the defined obtuse posterior angles, disc without medial impression or fovea. *Scutellum* minute, round. *Elytra* subdepressed, distinctly wider than prothorax at base, sides parallel for the greater part, widely rounded at apex, margins not apparently serrulate. *Prosternum* moderately convex, its apical process subtruncate, metasternum sulcate, whole underside glabrous and very lightly punctate. *Dimensions*, ♂ 3 × 1 (+) mm., ♀ 4 × 1·5 mm.

Habitat.—Queensland: Ipswich (Queensland Museum); Western Australia: Beverley (J. W. O. Tepper), in South Australian Museum.

Two ♂ from Beverley and two ♀ from Queensland are, I consider, conspecific. I am doubtful as to the true generic position, since the rather strongly bisinuate base of pronotum excludes it from *Anilara*, the widely separated and parallel eyes, the noncordate and nonsulcate pronotum exclude it from *Notographus*. The

antennary cavities are only visible from below and are without any associated carina. On the whole it would seem to be most at home in ***Pseudanilara***.

Type in Queensland Museum.

PSEUDANILARA PILIVENTRIS, n. sp.

Oblong, whole surface subnitid coppery bronze, pilose; the underside especially densely clothed with long recumbent silvery hair.

Head not wider than pronotum at apex, eyes prominent, space between eyes wide, their inner margins lightly converging behind, surface thickly pilose. *Prothorax*: Apex nearly straight, anterior angles wide, base strongly bisinuate, posterior angles acute and subfalcate; widest at base, sides lightly and arcuately narrowed to apex, disc alveolate-punctate, coarsely so at sides, sparsely pilose. *Scutellum* small and circular. *Elytra* as wide as prothorax at base, sides subparallel (feebly widened behind middle), margins of basal half rather strongly serrulate, surface rather coarsely and deeply alveolate-punctate, with clothing of white hair, sparse near suture, thicker towards sides. Underside coarsely alveolate-punctate, the punctures of the pronotum deep, square and with pronounced cell walls, those of the abdomen much shallower, though scarcely smaller, the hair especially dense on the abdomen. *Dimensions*, 4·5 × 1·5 mm.

Habitat.—South Australia: Lucindale (A. M. Lea).

A single ♀ example before me differs from the four described species in smaller size, colour, surface sculpture and clothing.

Type in the South Australian Museum.

GERMARICA Blkb.—The original description of the antennae of the genotype *G. casuarinae* Blkb. (Text-fig. 1) would seem to require considerable modification, unless the insect described from South Australia is widely different from the common species generally known under this name, of which I have numerous examples ranging from South Queensland to Victoria and Tasmania—obtained by beating certain Casuarine trees in summer. The antennae, when at rest, extend well beyond the head to about one-third the length of prothorax and, while the apical seven joints are widened and serrated, there is nothing that even remotely resembles the antennal club of *Syndesus* in the Lucanidae, as suggested. Dr. Obenberger has recently added two species, *G. blackburni* and *G. carteri* (*Entomologische Blätter*, 1923, p. 114), of which I have determined the first, and possibly the second, both from Queensland. I find two undescribed species amongst some Buprestidae sent from the South Australian Museum as follows:

GERMARICA ELATA, n. sp.

Oblong, less than three times longer than wide, subnitid bronze black, glabrous.

Head convex, much narrower than the apex of prothorax, eyes not prominent, space between eyes about the width of one eye; sparsely punctate. *Prothorax* tumid, apex and base straight, sides widely rounded, widest in front of middle, here wider than elytra; anterior angles very wide, posterior well defined and obtuse, disc strongly, transversely strigose and finely rugose; antennae nearly extending to base of prothorax, apical seven segments serrated, but not widely so. *Scutellum* rather large, triangular with rounded sides. *Elytra* moderately convex, as wide as prothorax at base, sides parallel, basal margin emphasized by transverse sulcus immediately behind it; disc covered with fine distinct punctures on a surface that is densely and microscopically punctate. Underside minutely

regularly punctate, the punctures round and not closely placed, the pronotal punctures more evident, the apical segments of abdomen sublaevigate. *Dimensions*, 3 (+) × 1·3 mm.

Habitat.—Queensland: Bowen (in South Australian Museum).

A single ♀ example bearing Mr. A. Simson's number label and the words "Bowen, on mimosa", is relatively wider and more strongly sculptured than *G. blackburni* Obenb., the prothorax of which is widest in posterior third, with the base angles rectangular.

Type in the South Australian Museum.

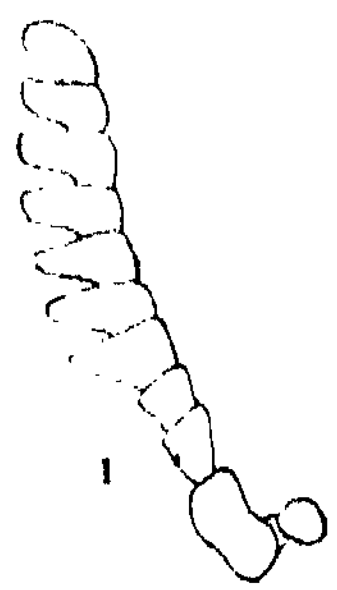
GERMARICA ABBREVIATA, n. sp.

Oblong, dull bronze-black. The head and pronotum very similarly formed to that of the former species; the pronotum less tumid, the sides evenly rounded, widest at middle, the posterior angles less widely obtuse. The sculpture of the whole upper surface is closer and coarser than in *G. elata*; that of the elytra showing a slight tendency to transverse rugosity. The underside more densely and strongly punctate. *Dimensions*, 2 (+) × 1 (vix) mm.

Habitat.—Western Australia (Blackburn Coll.).

A single example is wider and shorter than usual in the genus, but it is certainly congeneric with *G. elata*.

Type in South Australian Museum.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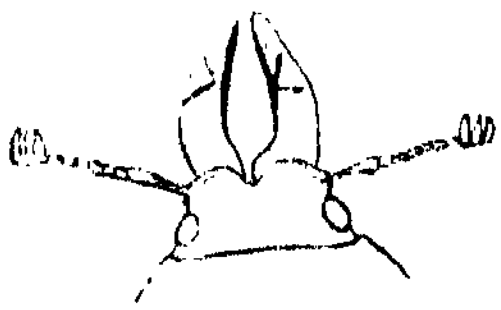
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3

Text-figures 1-3.
1. Antenna of *Germarica casuarinae* Blackb. ♀ (× 60).
2. *Lamprima imberbis*, n. sp. Head, seen from above.
3. *Lamprima imberbis*, n. sp. Head, seen from side.

Family Lucanidae.

LAMPRIMA IMBERBIS, n. sp. (Text-figs. 2-3.)

Dark coppery-bronze, mandibles, oral organs, tarsi, underside of tibiae and greater part of antennae metallic-blue, the flabellae opaque grey-brown.

Head: Eyes rather prominent, frontal area with large round punctures, well separated, without rugosity; antennae more slender, the flabellae shorter than in *L. varians* Germ.; mandibles long (about 4 mm.) *entirely hairless on both sides*, very nitid and narrow as compared with *varians*, rather acutely pointed at apex, each with a single conical, vertical tooth on upper margin, the lower internal margin nondentate; interior surface pustulose, some of these pustules showing from above as a close serration on lower margin; external surface sparsely punctate. *Prothorax* much more coarsely punctate than in *L. varians*, the

punctures large, round and more sparse, especially towards sides and apex; lateral fovea very large, almost filling the lateral angle. *Scutellum* semicircular, bearing about 8 large punctures. *Elytra*: The punctures smaller than on pronotum, but much larger than the corresponding punctures on *varians*; mesosternal process sharply carinate (in *varians* rather widely convex); everywhere on underside, pro-, meso- and metasternum, abdomen and legs the punctures are coarser than the corresponding punctures in *varians*. *Dimensions*, including mandibles, 22 × 9 mm.

Habitat.—New South Wales: Dorrigo (W. Heron).

A single male in the South Australian Museum is abundantly distinct from the well known *L. varians* Germ., with which, in dimensions and colour, it has the nearest affinity. The smooth, metallic mandibles entirely without hair, alone separate it from its congeners, the single, prominent, vertical tooth, as well as the unusual shape of the mandibles would also easily differentiate this species; while the punctures are everywhere larger and more pronounced than in Germar's species.

Type in the South Australian Museum.

Dryopidae.—The genus *Dryops* of Olivier (1791), being one year prior to *Parnus* of Fabricius, gives its name to an interesting family, which since 1864, when the Rev. R. L. King described seven species, has been little noticed by Australian entomologists. Since that date three species of *Helmis* have been added to our list, *H. tasmanica* Blkb., *H. simsoni* Grouv., and *H. v-fasciata* Lea.

These beetles are found in fresh water, generally attached to submerged sticks or stones, for which their unusually strong claws are adapted. They are unable to swim, are sluggish in their movements and, being often covered with slime or mud, easily escape notice. They have little affinity with true water beetles (Dytiscidae or Hydrophilidae) being more closely related to the Dascillidae, a member of which family was taken by A. M. Lea and myself (*Trans. Roy. Soc. S. Aust.*, 1919, p. 252) at Waratah, Tasmania, in company with *H. tasmanica* Blkb.

The following new species were taken by Messrs. Nicholson, in New South Wales, and F. E. Wilson and C. Barrett, in Victoria, the last mentioned naturalist taking them in considerable quantity, showing the great prevalence of a comparatively few species common to Tasmania, Victoria and alpine New South Wales. These are: *H. tasmanica*, *H. nicholsoni*, *H. simsoni* Grouv., *H. 4-plagiata* and *H. 9-notata*.

Of the other genera of the family I have seen only a single specimen of *Hydrethus* (described below) besides King's species, while the type of *Limnius 4-maculatus* King, being glued to a card, has not been examined as to its underside by me.

Table of Helmis (*Dryopidae*).

1.	Upper surface black	2
	Upper surface bronze	8
	Upper surface with white or yellow maculae	9
2.	Elytra regularly striate-punctate	3
	Elytra with only three evident striae	*polita* King
		punctulata King
3.	Elytral intervals more or less convex	4
	Elytral intervals flat	5
4.	Size large (5 mm. long) all intervals convex	*nicholsoni*, n. sp.
	Size small (2 mm. long) sutural intervals, only, convex	*angusta*, n. sp.
5.	Form widely ovate	6
	Form elongate-ovate	*wilsoni*, n. sp.

6. Pronotum trisulcate .... *montana* King
Pronotum nonsulcate 7
7. Prothorax widest at base .... *allynensis*, n. sp.
Prothorax widest at middle .... *simsoni* Grouv.
8. Elytral intervals convex, colour blackish-bronze .... *metallica* King
Elytral intervals flat, colour violet-bronze .... *aerata*, n. sp.
9. Size large, 5 mm. long .... *tasmanica* Blkb.
Size smaller 10
10. Pale markings limited to elytra .... *quadriplagiata*, n. sp.
Pale markings also on pronotum 11
11. Pronotum with elongate costae (more or less yellow) .... *pallidipes*, n. sp.
Pronotum without such costae 12
12. Elytra with zig-zag fascia .... *v-fasciata* Lea
Elytra with irregular marking (chiefly at base and shoulder) .... *novem-notata* King

HELMIS NICHOLSONI, n. sp.

Ovate, moderately convex, nitid black, antennae, coxae, tibiae and tarsi red.

Prothorax widest at basal third, thence obliquely and subsinuately narrowed to apex, more abruptly narrowed to base; anterior angles rounded, the posterior obtuse; base lightly bisinuate; sides explanate throughout; anterior part of disc forming a convex hood, divided from basal half by a wide Y-shaped depression, its stem not extending to base; on each side of this stem a tumid area; the whole pronotum strongly and rather closely punctate. *Scutellum* large and suborbicular. *Elytra* slightly wider than prothorax at base, humeral angle defined, sides nearly straight, slightly widest behind middle, thence rather sharply narrowed and feebly sinuate near apex, apical declivity moderately steep; striate-punctate, with large, squarish punctures occupying the whole striae and forming crenulations on their sides; striae and punctures continuous from base to apex, the punctures less defined near base and smaller near apex; intervals narrow and nitid, the sutural interval wider than the rest. Sternum and middle area of abdomen coarsely punctate, the sides of abdomen paler in colour and nearly smooth, apical segment with a fringe of pale hairs. *Dimensions*, 5 x 2 (vix) mm.

Habitat.—New South Wales: Mt. Kosciusko (A. J. Nicholson); Victoria: Fern Tree Gully and Warburton (F. E. Wilson).

Two examples taken with others by Mr. Nicholson, Lecturer in Entomology at the University of Sydney, after whom I name it, are readily distinguished from all described Australian species except *H. tasmanica* Blkb., by their larger size. From *tasmanica* it is separated by the absence of testaceous markings, its nitid surface and coarser sculpture. Mr. Nicholson also took *H. tasmanica* Blkb. at the same time, thus adding another link in the long chain of evidence showing zoological relations between Tasmania and Alpine Australia.

Type in the Macleay Museum.

VAR. H. BICOLOR.—Elytra tawny-yellow, save a wide sutural patch and a narrow marginal area black. Two examples taken by Mr. F. E. Wilson at Millgrove, Victoria, apparently differ only in colour from *H. nicholsoni*.

N.B.—The earlier spelling *Helmis* replaces *Elmis*.

HELMIS ALLYNENSIS, n. sp.

Wide and robust, moderately nitid black, antennae and tarsi red, underside fuscous, the medial area black.

Head finely, densely punctate, eyes large, round and flat. *Prothorax* very convex, widest at base, thence arcuately narrowed and "hooded" towards apex, base strongly bisinuate, lateral margins narrowly horizontal, forming a small acute angle at apex, posterior angles obtuse; disc evenly and densely punctate as on head.

Scutellum large and circular. *Elytra* considerably wider than prothorax at base, humeri tumid and rounded; sides subparallel, with a narrow horizontal margin; rather abruptly and obliquely narrowed at apex; striate-punctate, the striae fine and rather shallow, punctures in striae small and regular; intervals flat and very minutely asperate. *Prosternum* punctate, sides of metasternum and of abdomen opaque and finely asperate, apical segment of abdomen minutely, longitudinally striolate. Legs elongate, tarsi together as long as the tibiae. *Dimensions*, 3·5 × 2 (vix) mm.

Habitat.—New South Wales: Allyn River near Eccleston (Mr. Nicholson).

Two examples (probably the sexes) show a species intermediate in size between *H. nicholsoni* Cart., and *H. metallicus* King, with a much finer elytral sculpture than the former.

Type in Macleay Museum.

Helmis aerata, n. sp.

Short and wide, nitid violaceous-bronze, antennae yellow as to the two basal joints (rest wanting).

Head punctate, eyes not prominent. *Prothorax*: Apex sinuate, anterior angles rather acute and prominent, posterior rectangular; widest behind middle, sinuate in front of middle, straight behind, a very narrow horizontal margin (scarcely explanate); disc sparsely and coarsely punctate, a light transverse depression, chiefly noticeable at sides, anterior lobe less convex than usual, two oblique longitudinal sulci extending from base to the transverse depression about half-way between scutellum and sides. *Elytra* of same width as prothorax at its junction, widening at shoulders, widest behind middle; striate-punctate, the seriate punctures large, round and closer than in *H. wilsoni*, intervals flat, each with two more or less regular rows of smaller punctures. Underside smooth. *Dimensions*, 2 mm. long.

Habitat.—Victoria: Fern Tree Gully (C. L. Barrett).

A short, wide species more brilliantly metallic and with flatter elytra than *H. metallica* King.

Type in Coll. Wilson.

Helmis angusta, n. sp.

Obovate, nitid black, antennae and legs red.

Head finely punctate, eyes large and prominent. *Prothorax* rather narrow, widest near base, sides arcuately converging to apex, apical third forming a convex hood, slightly projecting over head; base feebly bisinuate, lateral margins scarcely explanate, anterior angles acute, posterior widely obtuse; disc lightly and indistinctly punctate, a wide transverse sulcus at apical third and another, indistinct and interrupted, at basal third. *Elytra* wider than prothorax at base, widest behind middle, lightly striate-punctate; striae and punctures shallow, the latter rather small, intervals slightly wider than striae; both striae and intervals only well marked on sutural half, being obscured on the lateral half of each elytron by transverse ridges. Underside apparently impunctate. *Dimensions*, 2 (+) × 1 (+) mm.

Habitat.—Victoria (Mr. Charles Barrett).

A single ♂ example sent by the well known Victorian naturalist is nearest *H. metallica* King in size and general appearance. It is, however, a narrower species, especially as to the prothorax; the upper surface, especially the pronotum,

is much less clearly punctured and the elytral sculpture is more irregular than in King's insect.

Type in Coll. Carter.

HELMIS PALLIDIPES, n. sp.

Oblong, glabrous, head and pronotum black, the latter with apex and raised parts yellow, elytra brown suffused with yellow, underside brown; legs and antennae testaceous; base of femora brown.

Head nearly as wide as apex of prothorax; eyes large, round and prominent. *Prothorax* about as wide as long, widest at base, thence lightly and obliquely narrowed to the front, becoming more convex anteriorly, the apex produced in the middle forming a hood; base feebly bisinuate, lateral margins narrowly raised, all angles acute, the anterior forming a minute tooth; disc embossed with four wide costate impressions partly interrupted, one on each side of and near the middle, extending from apex to near the base, the others consisting of two elongate pustules near margins; the depressed area very finely punctate. *Scutellum* large and circular. *Elytra* wider than prothorax at base, humeri tumid, sides parallel for the greater part, apices separately rounded, the margins yellow; striate-punctate, having rather large, round punctures arranged in pairs of rows, the alternate intervals clearly raised. Underside glabrous and impunctate; legs very long, combined tarsi longer than tibiae, the last joint longer than the rest combined. *Dimensions*, 2·5 × 1 (+) mm.

Habitat.—New South Wales (Macleay Mus.); Queensland: Cairns district (A. M. Lea in the South Australian Museum).

One example in the Macleay Museum and nine from the South Australian Museum are labelled as above. The species is very distinct from all recorded Australian species by its pale testaceous legs, antennae, underside, and markings of the upper surface.

Type in the Macleay Museum.

HELMIS QUADRIPLAGIATA, n. sp.

Rather widely oval, convex; black, elytra with four large plagia of orange-red, two at base, two on apical declivity; antennae and tarsi red.

Head and pronotum finely and densely punctate. *Prothorax* widest in middle, anterior half more convex than the posterior; sides evenly rounded with a narrow horizontal margin, anterior angles scarcely defined, the posterior defined and obtuse; disc with two transverse sulci, the first behind the middle arcuate, with concavity pointing forward, the second straight close to base. *Scutellum* round. *Elytra* shortly obovate, wider than prothorax at base, greatest concavity in front of middle; lateral margin narrowly horizontal and minutely crenulated; striate-punctate, with rows of small punctures in well marked but narrow striae; intervals flat, wrinkled and minutely punctate; underside rather coarsely punctate; the abdomen longitudinally rugose. *Dimensions*, 3·4 × 1·5 mm.

Habitat.—Victoria: Fern Tree Gully, under stones (J. A. Kershaw), Monbulk (J. J. Walker), Belgrave, Beaconsfield and Wittlesea (C. Barrett); Tasmania: Nile River, Forester River and Interlaken (A. Simson).

Thirty-four examples examined from the National Museum, twenty-six from the South Australian Museum (Simson Coll.) and others from F. E. Wilson. Of the form and size of *H. simsoni* Grouv., but easily distinguished by the colour, as also by its finer sculpture, except where obscured by mud; apparently the commonest species in Tasmania and Victoria.

Type series in the National Museum.

HELMIS WILSONI, n. sp.

Elongate-ovate, black with a metallic gloss; legs and antennae yellow, apical joints of the latter infuscate, underside yellowish-brown, paler at sides.

Head strongly punctate, eyes large and rather prominent; antennae: joints 1-2 very wide, 3 very slender, scarcely longer than 4, 4-10 sublinear lightly successively widening, 11 ovate-acuminate, wider than 10. *Prothorax*: Apex very convex, base truncate, sides slightly explanate, especially at angles, feebly rounded at middle, sinuate behind, scarcely so in front; anterior angles rounded, posterior rectangular, a deep and wide transverse depression in front of middle, anterior part convex, whole disc sparsely but distinctly punctate. *Elytra* wider than prothorax at base, widest behind middle; striate-punctate; the two first striae more plainly indicated than the others; seriate punctures large, shallow and round, separated by about the width of two punctures, intervals flat and finely punctate, with light transverse wrinkles. Underside impunctate. *Length*, 3 mm. (vix).

Habitat.—Victoria: Lorne (Mr. F. E. Wilson).

Two examples taken are nearest to *H. metallica* King, with the type of which I have compared it and which has a wider prothorax, less narrowed in front, elytral intervals convex. It is smaller and narrower than the species I take to be *H. simsoni* Grouv., which has a more coarsely and densely punctate pronotum.

Type in Coll. Wilson.

HYDRETHUS LEAI, n. sp.

Opaque-black above, legs and underside red, antennae with basal joints red, rest obfuscate, whole surface rather densely clad with short pilose clothing.

Head: Sculpture obscured by clothing, eyes large and prominent. *Prothorax* widest at base, gradually narrowing to apex, sides nearly straight without lateral foliation, apical area convex, rounded in front, posterior angles acute, discal surface showing small, close punctures somewhat obscured by derm, without transverse depression, two short longitudinal sulci near base towards sides. *Scutellum* large, oval. *Elytra* considerably wider than prothorax at base, shoulders tumid; striate-punctate, the striae clearly defined near suture; seriate punctures large and distant, finer in sutural series, becoming coarser outwards. Underside with close, short recumbent hairs. *Dimensions*, 3·5 mm. long.

Habitat.—Cairns district (A. M. Lea).

A single example, set on its side on a card, does not show the antennae very clearly; these are inserted at margin of eyes, the segments are not linear, the last four or five subclavate; the forecoxae are transverse, not globular. The species is near *H. (Lutrochus) australis* King, from which it differs as follows: Form shorter, surface smoother, more finely sculptured, less convex, the pronotum more pointed at apex, its hind angles sharper; elytra more ovate, less constricted at sides; also the spiny tufts of hair (?) round the periphery of the pronotum seen in *H. australis* are wanting.

Type in South Australian Museum.

Tenebrionidae.

Synonymy.

Bradymerus (Isostira) crenatus Pasc. = *B. granaticollis* Fairm. Herr Gebien has kindly sent me a plesiotype, from Banda Island, of Fairmaire's species, which is clearly identical with Australian examples of *crenatus* Pasc.

Bradymerus raucipennis Black. = *B. seriatus* Geb. A cotype of *seriatus* Geb. from New Guinea is identical with Blackburn's species, which I have from Yeppoon, Babinda, and Coen River (Queensland).

Ceropria maculata Geb. = *C. bifasciata* Cart. (nom. praeocc.) = *C. quadriplagiata* Geb. An example of *4-plagiata* Geb., sent by the author, is identical with *bifasciata* Cart., for which Herr Gebien provided the name *maculata* in Cat. Junk.

TRICHOSARAGUS GRANULATUS, n. sp.

Short, widely ovate, convex; elytra and pronotal foliation red or yellow; head, pronotum and underside brownish-black, appendages reddish-brown, the elytra clothed, at least at sides, with short, pale hairs.

Head strongly transverse, epistome truncate, minutely granulate, antennae short and pilose, joint 3 as long as 4-5 combined, the apical four segments forming a gradually enlarging club, 9 and 10 transverse, 11 forming a pointed arch. *Prothorax* convex, widest near base, arcuate-emarginate at apex, bisinuate at base, sides rounded, lateral foliation rather wide, directed obliquely downwards, all angles acute, margins black and crenulated by nodules; disc regularly clothed with small round shining nodules. *Scutellum* forming a short, wide lamina. *Elytra* less than twice as long as head and prothorax combined, slightly narrower than prothorax at base, each with about 17 longitudinal series of small, dark nodules, the 5th, 9th and 13th rows more prominent (containing larger nodules) than the rest. Prosternum granulose, mesosternum with wide triangular notch; abdomen with long recumbent pile; underside in general, the wide epipleurae in particular, minutely granulose, the latter margined by nodules; tibiae strongly serrated on outside especially the fore tibiae, mid and hind tibiae fringed with hairs and strongly spined at apex—four being perceptible on hind tibiae; tarsi with bristly clothing. *Dimensions*, 5-7 × 3·5-4 mm.

Habitat.—Australia (Blackburn Coll. in South Australian Museum), South Australia (in Macleay Museum).

Three examples examined, two from the South Australian Museum, and one (the smallest and less strongly granulated than the others) in the Macleay Museum. It is near *T. pilosellus* Blkb. in form and structure, but with two differences that may later be deemed to suggest generic separation namely, the shorter and stouter antennae, and the very different elytral sculpture. Type in South Australian Museum.

N.B.—I think now that the genus *Trichosaragus* more fitly belongs to the subfamily Opatrinae—not far removed from *Caedius*.

NOTOCERASTES (gen. nov. Bolitophaginarum).

Elongate-ovate, subdepressed, head of ♂ armed, narrowed in front of eyes, not deeply inserted in the prothorax, sulcate beneath; eyes ellipsoidal, prominent, undivided. Antennae not quite reaching base of prothorax, joint widely nodose, 2 smaller, cup-shaped, 3-8 subconic, 3 nearly as long as 4-5 combined, 9-11 widely oval, forming a loose club. Labrum straight in front, maxillary palpi long, labial very short, last segment of each subulate; mentum transverse ciliated. Prothorax subcordate, margins crenated; metasternum elongate, body winged; anterior and intermediate coxae globose; about as wide apart as in *Dipsaconia*, epipleurae also as in that genus. Three visible basal ventral segments about equal in length, the two apical narrower but equal *inter se*. Legs rather long, tibiae little enlarged, shortly spined at apex; tarsi pilose beneath.

A genus apparently near *Ilyxerus*; but with antennal club not "validam compressam" and having quite a different elytral sculpture.

NOTOCERASTES BLACKBURNI, n. sp.

♂. Elongate, parallel, opaque chocolate-brown, more or less clothed with a yellowish pilose derm, showing in thickened patches on elytra, giving a mottled aspect to surface; legs and antennae red.

Head armed with horns springing from the sides of clypeus immediately in front of eyes, these longitudinally flattened, slightly incurved at tips with a small angular enlargement on upper (or posterior) margin of each near apex. Head widest at eyes, its sculpture concealed by derm, clypeus nearly straight. *Prothorax* depressed (convex only at sides) widest near front, apex with discal part nearly straight, the anterior angles rather acutely produced; base weakly sinuate, a wide medial part produced a little backward, sides lightly arched and narrowed from near front to base, more abruptly narrowed to front angles; posterior angles defined and obtuse; margins finely crenate; disc (where visible) closely punctate beneath a short, pilose derm, a shallow medial sulcus enlarging into a wider depression at base and apex. *Scutellum* transverse, oval. *Elytra* considerably wider than the prothorax at base, and at least thrice as long; parallel, shoulders nearly square, surface somewhat obscured by derm in irregular patches; striate-punctate, with about 10 rows of close, deeply impressed striae, besides a short scutellary row; the punctures in striae close and rather large, the intervals sharply raised and themselves punctate. Underside clothed with short recumbent hairs, abdomen sparsely punctate, post tarsi short, the first and fourth subequal in length.

♀ with the clypeal horn replaced by a slightly raised angular process; the antennal club less pronounced. The only example before me is paler in colour and smaller than the two males. *Dimensions*, ♂ 9 × 2·7 and 7 × 2·5 mm.; ♀ 6 × 2·1 mm.

Habitat.—♂. Dividing Range (Blackburn Coll. in South Australian Museum). ♂. N.S.W.: Wagga (Macleay Museum). ♀. Victoria: Melbourne (Ejnar Fischer in South Australian Museum).

Three examples labelled as above, the first having an attached note on its diagnosis in the handwriting of the late Canon Blackburn, after whom I name it.

Type in the South Australian Museum.

N.B.—The monotypic *Ilyxerus asper* Pasc. has never been identified in our collections. It would appear to be the nearest ally to *Notocerastes.*

The *Ulodes-Dipsaconia* group are very doubtfully separable from the Bolitophaginae, though Gebien has followed Pascoe in making a separate subfamily Ulodinae.

LYPHIA GRANDIS, n. sp.

Elongate, subcylindric, nitid castaneous.

Head densely and finely punctate, antennae very short, the apical four segments strongly transverse. *Prothorax* convex, as long as wide, apex rounded, slightly advanced in middle, base and sides nearly straight, anterior angles depressed and rounded, posterior obtuse; sides and base with a very narrow raised border, disc finely and uniformly punctate like the head; without foveae or medial line. *Scutellum* rather large, triangular. *Elytra* about as wide as prothorax at base, and two and a half times as long, whole surface irregularly punctate, but

seriate punctures discernible in subobsolete striae—these shown as darker lines. Underside finely and closely punctate, legs short, tibiae enlarged at apex. *Dimensions*, 7 × 2 (+) mm.

Habitat.—Queensland: Endeavour River (Macleay Museum).

Two examples labelled as above in the Macleay Collection show a species that is a giant compared with the two recorded (*australis* Geb. and *tasmanica* Champ.).

Type in the Macleay Museum.

ULOMA LATIOR, n. sp.

♂. Widely oblong, nitid black, oral organs, antennae, legs, coxae, epipleurae and parts of prosternum red.

Head short and wide, closely and finely punctate, eyes small, antennal orbits not prominent, joints 7-10 of antennae successively widened and closely compressed, 11 widely oval. *Prothorax*: Apex arcuate, base nearly straight, sides nearly straight on basal half, arcuately narrowing on front half, widest in front of middle; anterior angles defined and widely obtuse, posterior subrectangular; disc minutely and rather sparsely punctate, an oval depression near apex at middle. *Scutellum* rather small, arcuate-triangular. *Elytra* of same width as, and closely adapted to, prothorax; parallel for two-thirds of their length, widely rounded at apex; striate-punctate, with fine punctures almost concealed in fine, clear-cut striae; intervals flat and impunctate. *Prosternum* strongly, longitudinally rugose, meso- and metasterna clearly punctate, abdomen strigose; fore tibiae lightly curved, sparsely spinose, enlarged on apical half, abruptly narrowed in middle, mid tibiae less curved and spinose; hind tibiae straight, with margins entire.

♀ without pronotal impression, fore tibiae uniformly widened to apex and less curved. *Dimensions*, ♂ 9 × 4 (+) mm.; ♀ 10 (−) × 4·2 mm.

Habitat.—New South Wales: Kurrajong (Mr. Masters).

Two examples in the Macleay Museum are strikingly different in their ratio of length to breadth, from any other Australian species known to me. The prothorax is also much longer in proportion to the elytra than in *U. sanguinipes* F. (*laticornis* Pasc.). Thus, compared with a typical example of the latter, the dimensions of which are 11 × 4·2 mm., I find the following comparison: Ratio of length of pronotum to length of elytra, 3:7·5 (*sanguinipes*), 3:5·5 (*latior*); ratio of length to width of whole insect, 11:4·2 (*sanguinipes*), 9:4 (*latior*). Other distinctions from *sanguinipes* are the finer punctures of the pronotum and the flatter interstices of the elytra.

Type in the Macleay Museum.

ULOMOIDES MACLEAYI, n. sp.

♂. Red, the elytra with a darker irregular stain, short, depressed.

Head finely and closely punctate, its suture clearly impressed, antennae moderately long, 4-10 cupuliform, gradually widening to apex, 11 globular. *Prothorax*: Apex arcuate, base bisinuate, widest at middle, sides evenly rounded, anterior angles wide and lightly rounded off, the posterior subrectangular, margins very narrow (unseen from above), surface, like the head, finely and closely punctate, two elongate depressions near base. *Scutellum* triangular with rounded sides. *Elytra* of same width as prothorax at base, widening to the middle, apex rather widely rounded; striate-punctate, the striae not deeply impressed, seriate punctures small, regular and close (about the width of a puncture between each pair), intervals quite flat and microscopically punctate. Underside minutely

punctate, fore and mid tibiae not serrate on the upper margin, hind and mid tibiae finely serrated on the lower margin, the hind tibiae with a subangular enlargement near the middle, followed by a hollowing of the lower margin.

♀ with mid and hind tibiae scarcely serrated on inside, hind tibiae not enlarged or hollowed. *Dimensions*, 5 × 2 mm.

Habitat.—North-west Australia (Macleay Museum).

Three examples in the Macleay Collection show a species near *Ulomoides humeralis* Blkb., in its short, flat form, carinate tibiae, the latter unarmed externally. Besides its larger size it may be distinguished from *U. humeralis* (of which a cotype is before me) by its evidently coarser punctures of the pronotum, and the wider antennal segments.

Type in the Macleay Museum.

PLATYDEMA MACLEAYI, n. sp.

Oval, very convex; head, pronotum, elytral fascia and apex, underside and appendages red, remaining area of elytra black.

Head minutely punctate, eyes large, each eye nearly as wide as space between eyes, antennae sub-moniliform, less widened apically than usual. *Prothorax*: Apex nearly straight, base feebly bisinuate, sides lightly and arcuately converging from base to apex, anterior angles depressed and widely rounded, posterior angles acute, disc not perceptibly punctate, with two basal, linear, foveae. *Scutellum* triangular. *Elytra* widely oval, as wide as prothorax at base, widest at middle, apex widely rounded, a premedial yellow fascia, widely interrupted at suture and extending to sides, apex widely red; striate-punctate, having rather large punctures placed in clear-cut striae; intervals a little convex and impunctate. Underside lightly striolate. *Dimensions*, 3-3·5 × 1·5-1·7 mm.

Habitat.—Queensland: Kuranda (Dr. E. W. Ferguson and the Macleay Museum).

Three examples examined—two from the Macleay Museum, one long ago given me by Dr. Ferguson in my collection.

In my table (These PROC., 1917, p. 702) it would stand near *P. aries* Pasc., a much larger species having the pronotum and extreme apex of elytra black. It is very distinct from the oblong and depressed *P. bicinctum* Champ.

Type in the Macleay Museum.

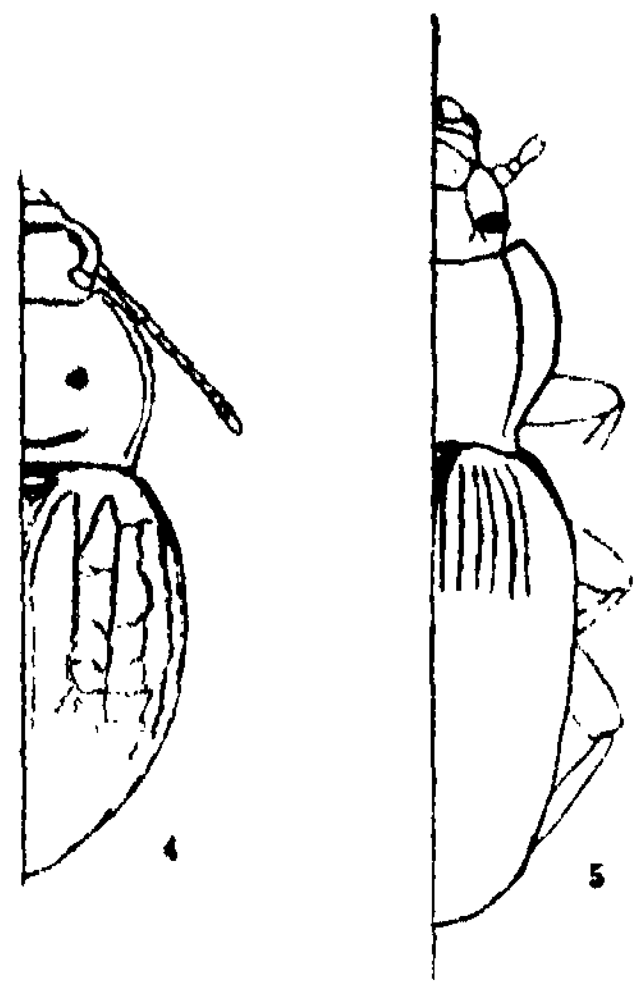
Platydema pascoei Macl. = *P. victoriae* Blackb.—I have lately examined Macleay's type and find that it is not synonymous with *P. tetraspilotum* Hope, as stated by Champion (*Trans. Ent. Soc. Lond.* 1894, p. 373), but is the species described by Blackburn in 1893 as *P. victoriae*, which name must therefore be sunk. It is probably the commonest Tenebrionid in Australia that I have found in quantity under dead Eucalyptus boughs from Victoria to North Queensland. *T. tetraspilotum* Hope I have only found under Eucalyptus bark.

NYCTOZOILUS MACLEAYI, n. sp. (Text-fig. 4.)

Elongate-ovate, opaque black above, subnitid beneath, antennae and tarsi reddish.

Head densely punctate, labrum prominent, clypeus truncate in front, its sides oblique, meeting the antennal orbits at a wide angle, the latter arcuately raised; antennae nearly reaching base of prothorax, 3 nearly as long as 4-5 combined, apical four wider than the rest. *Prothorax* rather flat, apex strongly emarginate, the anterior angles acute and directed forward; base subtruncate, widest behind

middle, thence arcuately converging in front, rather abruptly sinuate behind, the posterior angle forming a subacute tooth; lateral margins feebly and irregularly crenulate; extreme border rather thick and reflexed, the adjacent area moderately concave; disc closely and distinctly punctate, with two foveate depressions near middle, an arcuate transverse sulcus between these and the base, and a short smooth medial line between the foveae, the foveae, medial laevigate mark and transverse sulcus forming a comical caricature of an animal's face. *Scutellum* widely transverse. *Elytra* elongate-obovate, as wide as prothorax at base, soon



Text-figures 4-5.
4. *Nyctozoilus macleayi*, n. sp.
5. *Cardiothorax sexsulcatus*, n. sp.

widening to the rounded shoulders, widest behind middle; reticulate-punctate, scarcely costate (three irregularly undulate raised lines almost continuous from base to apical declivity) with transverse impressions forming irregular reticulations, the intervening areas everywhere showing large round punctures, with the usual lateral row of larger punctures bounded externally by a narrow lightly reflexed border; gular region coarsely, sternal area strongly, abdomen finely, punctate. *Dimensions*, 15 × 7 mm.

Habitat.—New South Wales: Coonabarabran.

A single ♂ example in the Macleay Museum bears a locality label in the handwriting of the late Mr. G. Masters and adds another distinct species to a large genus, of which the individuals are often rare. Mr. T. G. Sloane and I collected assiduously in this district in Nov., 1923, without meeting it. It should stand in my table near *N. irregularis* Blackb.

Type in the Macleay Museum.

HYPAULAX PYGMAEUS, n. sp.

Ovate; head and pronotum subopaque, elytra and underside nitid black.

Head and pronotum microscopically punctate,* epistoma evenly arcuate, antennal orbits wide, little raised and lightly sinuate anteriorly; antennae short,

* Minute punctures just perceptible with a Zeiss binocular.

1-7 oval, 8-10 increasingly transverse, 11 oblong-ovate, twice as long as 10. *Prothorax* widest in front of middle, apex produced in middle, base truncate, anterior half of sides (including the depressed angles) widely rounded, posterior half sinuately converging to the obtuse posterior angles; lateral margins entire, extreme border very narrow (without interior sulcus), basal border slightly wider. *Scutellum* small, triangular. *Elytra* wider than prothorax at base, obtuse humeral angle sharply defined; sulcate-punctate, the seriate punctures half concealed in deep sulci; intervals convex and impunctate; underside of head and prosternum finely and densely punctate, abdomen very minutely so; legs and tarsi shorter than usual, the latter clothed with fawn-coloured tomentum. *Dimensions*, 9-10 × 3·5-4 mm.

Habitat.—Northern Territory (Port Darwin).

A pair, probably the sexes, in the Macleay Museum are the only specimens I have seen. About the same length as, but narrower than *H. nanus* Cart., the elytral sculpture is nearest that of *H. ovalis* Bates, but the sulci are more pronounced, the seriate punctures more concealed than in that species.

Type in Macleay Museum.

CARDIOTHORAX SEXSULCATUS, n. sp. (Text-fig. 5.)

Head and pronotum bronze-black, elytra bronze, underside black, whole surface nitid.

Head: Epistoma widely triangular, the usual frontal impression with a few punctures near centre; basal half of antennae nitid, apical half opaque and reddish. *Prothorax* widest in front of middle, front angles rather sharply rounded, sides strongly and arcuately converging behind, with a wide sinuation preceding the acute dentate hind angle, this directed obliquely outward, and slightly reflexed at tip; base bisinuate with a backward curve towards the posterior angles; foliate margins wide for the greater part (with about three setae on each), strongly narrowed near base, a defined separating sulcus; extreme border narrowly reflexed, disc smooth (in one example two small foveate punctures near base), deep medial sulcus not quite reaching base. *Scutellum* small, triangular. *Elytra* considerably wider than prothorax at base, shoulders well rounded, epipleural fold evident; each with six deep sulci, intervals convex and impunctate, the 5th interval slightly wider than the rest, the lateral area showing three scratch-like strioles. Underside impunctate. *Dimensions*, 18-18·5 × 6·5-7 mm.

Habitat.—New South Wales: Barrington Tops (Mr. J. Hopson).

Mr. Hopson has lately sent two examples, both I think ♀, of a species that is quite distinct from the other four species peculiar to this prolific district. In general facies it is nearest *C. hopsoni* Cart., which, however, has eight distinct sulci on each elytron, flatter intervals, pronotum with narrower foliation, the posterior sinuation much less marked, *inter alia*. *C. nasutus* Cart. and *C. harrisoni* Cart., which also have six sulcate elytra, are otherwise distinct, notably in the absence of defined posterior dentation of the pronotum.

Type in Coll. Carter.

OMOLIPUS NITIDUS, n. sp.

Elongate-oblong, convex. Head, pronotum, underside and legs black, elytra dark olive-green, its suture faintly purple, antennae and tarsi reddish, whole surface very nitid.

Head minutely and sparsely punctate, front outline from eye to eye forming almost a complete semicircle, antennae having the five apical segments successively widened. *Prothorax* narrower than usual, about as long as wide, sides very lightly widened, slightly advanced in the middle; anterior angles depressed and obtuse, the posterior rectangular, lateral margins evident from above, a transverse sulcus near base; an oval depression in front of this at middle, two small foveate punctures on disc, this very nitid and minutely punctate. *Scutellum* small. *Elytra* slightly wider than prothorax at base, sides subparallel to basal third, thence converging to a somewhat pointed apex; disc very finely striate-punctate, the striae bearing minute, shallow, distant punctures. Underside almost impunctate. *Dimensions*, 9 × 3 mm.

Habitat.—Queensland: Blackall Ranges (F. E. Wilson).

A single ♂ example is very distinct from its congeners by its parallel, subcylindric form, brilliantly nitid surface and extremely faint sculpture. In the last character it is nearest *O. laevis* Pasc., which belongs to the widely ovate section (Group i of my Tabulation, these Proc., 1915, p. 535); while in structure and form it is nearest to *O. angustus* Cart. of Group ii.

Type in Coll. Wilson.

THE GASTEROMYCETES OF AUSTRALASIA.

iv. SPECIES OF THE GENUS GEASTER.

By G. H. CUNNINGHAM, Government Mycologist, Wellington, N.Z.

(Plates ii-vii.)

[Read 31st March, 1926.]

Members of the genus *Geaster* are popularly known as "earth-stars", on account of the stellate nature of the expanded exoperidium of certain species. All are saprophytic, growing upon vegetable debris on the forest floor, under hedges or in open pastures. Most species have a wide but sparse distribution, for the greater number have been found on all continental areas. Five species are confined to this biological region.

Structure of the Mature Plant.

The mature plant is seen to consist of two well-defined groups of tissues—the exoperidium and the endoperidium.

Exoperidium.

This structure is usually split to about the middle into a variable number of rays, 5-14 or more, but this number is not constant, even in the same species. The rays may be expanded, revolute or involute; those plants possessing rays which are involute when dry (or during dry weather) are said to be hygroscopic, those with rays which remain expanded (or revolute) are said to be non-hygroscopic. The base of the exoperidium may be saccate, when it usually partially encloses the endoperidium, or convex, when the endoperidium appears as if raised upon a small dome. The exoperidium consists of three well-defined tissues: (1) The mycelial or outer layer; (2) the fibrillose or middle layer; and (3) the fleshy or inner layer.

(1) Mycelial layer.—This, the exterior layer, is well seen in plants ere they have expanded. If the plants are epigaean, the exterior is seen to be either felted-tomentose (*G. velutinus*) or comparatively smooth (*G. triplex*). In the former case the whole of the exterior is covered with a dense palisade, 1-2 mm. thick, of stout, persistent hyphae; in the latter the mycelial layer is almost wanting, and forms a thin, frequently evanescent layer of thin-walled hyphae arranged radially. This soon flakes away, exposing the fibrillose layer.

If plants are hypogaean, the mycelial layer is composed of long hyphae arising from all parts of the plant and ramifying for some distance into the substratum. Consequently, when such plants become expanded, the mycelial layer either holds the exoperidium permanently to the substratum, or, as more frequently happens, the exoperidium is torn away from the substratum, the mycelial layer then holding firmly to the exterior of the exoperidium quantities of vegetable debris. This debris may persist, but as the plant becomes weathered usually flakes away in irregular patches.

In three species (*G. fenestriatus*, *G. minus* and *G. radicans*) the two inner layers frequently split away from the mycelial layer (which remains as a cup

attached to the substratum) save at the apices of the rays, and become arched upwards until they assume a strongly fornicate appearance. Such a condition is common with *G. fenestriatus*, less so with *G. minus*, and apparently rare with *G. radicans*. This fornicate condition is not of specific value, for collections are frequent in which both fornicate and non-fornicate forms are present.

(2) Fibrillose layer.—This tissue consists of intricately woven hyphae of two kinds, arranged with their long axes predominantly radial. The inner portion (next the fleshy layer) is strengthened by numerous thick-walled hyphae similar to those of the capillitium. The fibrillose layer is at the base attached to the endoperidium and, when present, the columella and pedicel. The whole tissue is tough and membranous, and in old plants is frequently the only remaining tissue of the exoperidium.

(3) Fleshy layer.—This inner tissue is pseudoparenchymatous. In freshly expanded plants it is soft, thick and flesh-coloured; after exposure it shrinks considerably, changes to some shade of brown and often becomes rimose. Frequently it flakes away in irregular patches, and occasionally may peel from the fibrillose layer and assume a cupulate appearance around the base of the endoperidium (*G. velutinus* and *G. triplex*); indeed, it was the presence of such a structure that led to the erection of the latter species.

Endoperidium.

This structure is attached to the base of the exoperidium, and encloses the gleba, consisting of capillitium and spores. In texture it is membranous or papyraceous, consisting of numerous interwoven, partially gelatinized hyphae. The exterior is usually glabrous, but may be farinose (*G. Bryantii*), tomentose, covered with roughened particles, or even coated with a substance which gives to it an appearance as if coated wtih a heavy layer of chalk (*G. calceus*). The colour ranges from dingy white to dark umber-brown.

In those species in which the base of the exoperidium forms a small dome, the endoperidium is usually pedicellate, being attached at its base by a pedicel of varying length and thickness; in saccate plants it is usually sessile, attached by a broad base and partly surrounded by the saccate base of the exoperidium.

At the apex is a solitary stoma (sometimes two are present, as in *G. ellipticis*) through which the spores escape. This opening may be merely a poorly defined aperture, scarcely discernible from the endoperidium—when the species is said to possess a naked, indefinite mouth; or the stoma may be enclosed within a definite peristome, when the species is said to be peristomate. Should the peristome be regularly pleated or fluted it is said to be plicate; if silky and made up of innumerable parallel fibrils arranged radially around the stoma, it is said to be fibrillose. The significance of these differences will be made apparent under the section dealing with specific characters.

Gleba.—The whole of the tissues enclosed within the endoperidium is known as the gleba.

The spores are globose or less frequently subglobose, usually some shade of brown and, with one exception (*G. subiculosus*), verrucose or verrucose-echinulate. Their size and epispore markings are useful diagnostic characters.

The capillitium consists of innumerable fusiform or cylindrical, coloured, simple, continuous hyphae. They arise from the columella and less abundantly from the inner surface of the endoperidium. Their function is unknown, but they are supposed to aid in spore dispersion.

F

The columella arises from the base of the exoperidium (fibrillose layer) and is a continuation of the pedicel, when present. It is usually cylindrical, but may be clavate or even globose. Its presence in mature plants is often difficult to detect, but it may be readily seen when unexpanded plants are sectioned.

Specific Characters.

In genera containing numerous species it is customary to seek certain characters whereby the genus may be split into sections, and these in turn subdivided until at last only two or three closely related species remain together. Ultimately it should be possible on these lines so to arrange a key that each species is separable from the other; unfortunately this is often difficult owing to variation among closely related species breaking down artificial divisions that might otherwise be used.

The procedure in the preparation of such a key is to seek certain group characters sufficiently constant and well marked as to allow of group separation. In the genus *Geaster* these major or group characters have differed according as to the individualistic interpretation of their value. For example one worker has based his major divisions of the species on whether they are pedicellate or sessile; another on whether they are fornicate or saccate; a third on whether hygroscopic or non-hygroscopic. In the opinion of the writer these divisions are open to criticism because in all, closely related plants are widely separated.

He would first subdivide the genus into two main sections:

A. Mouth enclosed within a definite peristome.

B. Mouth naked (and usually indefinite).

And would further subdivide section A into

a. Peristome sulcate (Pl. ii, fig. 1);

b. Peristome fibrillose (Pl. ii, fig. 3);

thus grouping all species under three well-defined sections.

Mouth characters are sometimes spoken of as being sulcate or even, definite or indefinite, but these terms have in the past been so loosely applied as to have little value.

These three main sections may then be subdivided according to whether the exoperidium is hygroscopic or non-hygroscopic, and the endoperidium pedicellate or sessile. But these characters are by no means constant, and one often encounters plants difficult to place under one sub-section or the other.

All descriptions are original, save where otherwise stated, and have been drawn up from material examined by the writer. Details of the development and cytology of the epigaean species *G. velutinus* have been worked out by the writer, and will be pulished elsewhere.

The writer is again indebted to Dr. J. B. Cleland, Adelaide University, for the loan of all specimens in his extensive herbarium; to Mr. C. C. Brittlebank, Victorian Department of Agriculture, for the loan of specimens in the Herbarium of the Science Branch of the Victorian Department of Agriculture; to Mr. L. Rodway, Government Botanist, Tasmania, for the loan of specimens from his collection; and to his friend Mr. H. Drake, of this Laboratory, for all photographs reproduced herein.

GEASTER Micheli.

Fries, *Syst. Myc.*, iii, 1829, p. 9.—*Geastrum* Pers., p.p., *Syn. Meth. Fung.*, 1801, p. 130.—*Cycloderma* Klotzsch, *Linnaea*, vii, 1832, p. 193.—*Plecostoma* Cda., *Anleit.*, 1842.

Peridium globose to acuminate, epigaean or hypogaean. Exoperidium of three layers, an external mycelial layer, a middle fibrillose layer, and an internal fleshy layer; at first closely investing the endoperidium, but distinct, splitting at maturity from the apex downwards into several stellate rays, which may be revolute or involute. Endoperidium pedicellate or sessile, membranous or papyraceous, thin, glabrous or variously roughened; dehiscing by a single apical orifice, which may be peristomate or naked.

Gleba of capillitium and spores; columella present or wanting; capillitium threads simple, long, apically acuminate, arising from the columella or inner wall of the endoperidium. Spores globose or subglobose, continuous, coloured, rough or smooth. Basidia sterigmate, 4-8 spored.

Habitat.—Solitary, in groups, or caespitose on the ground or vegetable debris in open pastures, under hedgerows or on the forest floor.

Distribution.—World-wide.

This genus contains about thirty species, of which twenty-three are found in this biological region. It is included in the Lycoperdaceae, a family containing in addition about six other genera.

Artificial Key to the Species.

- A. Mouth peristomate.
  - Peristome sulcate.
    - Exoperidium not hygroscopic.
      - Endoperidium pedicellate.
        - Endoperidium smooth (or farinose, not roughened).
          - Peristome circular.
            - Base of the endoperidium smooth or striate .. 1. *G. pectinatus*
            - Base of the endoperidium plicate .. .. 2. *G. plicatus*
            - Base of the endoperidium with a collar-like ring .. .. 3. *G. Bryantii*
          - Peristome elliptical .. .. 4. *G. ellipticis*
        - Endoperidium roughened-verrucose.
          - Peristome concolorous .. .. 5. *G. Hariotii*
          - Peristome surrounded by a silky, differently coloured zone .. .. 6. *G. Berkeleyi*
      - Endoperidium sessile or sub-pedicellate .. .. 5. (*G. Hariotii*)
    - Exoperidium hygroscopic.
      - Endoperidium pedicellate.
        - Spores 6-8 μ .. .. 7. *G. campester*
        - Spores 4-5·5 μ.
          - Endoperidium asperate .. .. 8. *G. Clelandii*
          - Endoperidium smooth .. .. 9. *G. Smithii*
      - Endoperidium typically sessile .. .. 10. *G. Drummondii*
  - Peristome fibrillose.
    - Exoperidium not hygroscopic.
      - Endoperidium pedicellate.
        - Plants typically minute .. .. 11. *G. minus*
        - Plants typically large .. .. 12. *G. limbatus*
      - Endoperidium sessile.
        - Exoperidium externally felted-tomentose or tomentose-strigose.
          - Plants large, 3-6 cm. .. .. 13. *G. velutinus*
          - Plants small, 1·5-2 cm. .. .. 14. *G. mirabilis*
        - Exoperidium externally smooth, or almost so.
          - Spores smooth or nearly so .. .. 15. *G. subiculosus*
          - Spores verrucose-echinulate or verrucose.
            - Spores 2·5-3·5 μ .. .. 16. *G. saccatus*
            - Spores 4-5 μ .. .. 17. *G. triplex*
            - Spores 7-8 μ .. .. 18. *G. australis*

Exoperidium hygroscopic.		
Endoperidium pedicellate	19.	*G. arenarius*
Endoperidium sessile		(*G. mammosus*)
B. Mouth naked.		
Exoperidium not hygroscopic.		
Endoperidium pedicellate.		
Exoperidium typically fornicate	20.	*G. fenestriatus*
Exoperidium revolute		(*G. rufescens*)
Endoperidium sessile	21.	*G. fimbriatus*
Exoperidium hygroscopic.		
Spores 6-7 μ	22.	*G. floriformis*
Spores 4-5 μ	23.	*G. simulans*

1. GEASTER PECTINATUS (Persoon) Lloyd. Plate iii, figs. 7, 8.

Geastreae, 1902, p. 15.—*Geastrum pectinatum* Pers., *Syn. Meth. Fung.*, 1801, p. 132.—*G. minimum* Chev., *Fl. Env. Paris*, i, 1826, p. 360.—*Geaster striatus*, Fr. p.p., *Syst. Myc.*, iii, 1829, p. 13.—*G. Schmidelii* Vitt., *Mon. Lyc.*, 1842, p. 157.—*G. calyculatus* Fcl. *Symb. Myc.*, 1870, p. 37.—*G. umbilicatus* Quel., *Mem. d. Soc. Em. d. Montbeliard.* ii, 1873, t. 3.

Plants at first globose, submerged, becoming superficial and expanded when 3-5 cm. across. Exoperidium split to about the middle into 5-12 subequal, acute rays which are expanded or sub-revolute; fleshy layer brown, unequally flaking away in irregular patches, leaving exposed the ochraceous fibrous layer; exterior covered with debris held by the adnate mycelial layer, which is persistent but tends to flake away; base concave.

Endoperidium pedicellate, subglobose, depressed-globose or urceolate, 1-2 cm. diam., brown or lead-coloured, often farinose, base tapering into the pedicel, striate or not, apophysis present or absent; pedicel slender, 3-6 mm. long. Peristome sulcate, prominent, narrowly conical, concolorous.

Gleba ferruginous; columella inevident; capillitium threads† tinted, fusiform, simple. Spores globose, 5·4-6·2 μ; epispore dark umber, moderately and coarsely verrucose, reticulate.

Habitat.—Solitary or in groups on vegetable debris on the ground.

Distribution.—Britain; France; Austria; Sweden; North America; Australia; New Zealand.

New South Wales: * Milson Island, Hawkesbury River, Apl., 1913.

South Australia: * Black Hill, Adelaide, June, 1906, F. R. Zeitz (3 coll.); * Port Elliot, Aug., 1918, D. I. Cleland; * Glen Osmond, Dec., 1921; * Port Lincoln, May, 1923, Det. Lloyd No. 885 as *G. Schmidelii*; * National Park, May, 1923.

New Zealand: ** Dunedin, Otago, Aug., 1921, Miss H. K. Dalrymple; ** Otaki Forks, Wellington, May, 1922, E. H. Atkinson.

A darker, smaller form is by certain systematists separated as *G. Schmidelii*, but as all intermediate forms may occur in the same collection, separation, save at the extremes, is not practicable.

Two other species, *G. Bryantii* and *G. plicatus*, so closely resemble *G. pectinatus*, save in one or two minor characters, as to make separation a matter

† The capillitium threads are very similar in all the species examined, therefore they will not again be described save where they diverge from the normal.

* An asterisk indicates that the collection in question is in the herbarium of Dr. J. B. Cleland, Adelaide; and where the collection is preceded by an asterisk, but no collector given, it signifies that the collection was made by Dr. Cleland himself.

** A double asterisk preceding a collection indicates that the collection in question is in the herbarium of the writer.

of difficulty. For example, in one Australian collection there are plants which could be referred to *G. plicatus*, and others which could be placed under *G. Bryantii*. In a New Zealand collection one specimen could be placed under *G. plicatus*, the other under *G. pectinatus*. They are better considered as subspecies, and may be determined by the following characters:

Base of the endoperidium smooth or slightly striate .... *G. pectinatus*
Base of the endoperidium plicate .... *G. plicatus*
Base of the endoperidium with a well-defined collar or ring .... *G. Bryantii*

To these three subspecies the writer has added another, separated on account of the peculiar nature of the peristome, which is elliptical and not circular as in other species. In reality this structure consists of two peristomes merged so as to form a continuous opening. This is made apparent by the fact that two specimens in the collection each possess two distinct peristomes.

2. Geaster plicatus Berkeley. Plate iii, fig. 9.

Ann. Nat. Hist., iii, 1839, p. 399.—*G. tenuipes* Berk., *Fl. Tas.*, ii, 1860, p. 264.—*G. biplicatus* Berk. et Curt., *Proc. Am. Acad. Arts and Sci.*, iv, 1860, p. 124.

This subspecies is separated from *G. pectinatus* solely on account of the plicate base of the endoperidium, for in all other respects it is identical.

Distribution.—India; Bonin Is.; Ceylon; New Caledonia; South Africa; Australia; Tasmania; New Zealand.

South Australia: * Fullarton, Adelaide, May, 1923.

Victoria: Grantville, J. T. Paul (Herb. Vic. Dept. Agr.).

New Zealand: ** Lake Papaetonga, Wellington, Aug., 1919, G.H.C.; ** Sandhills, Weraroa, Wellington, Nov., 1919, E. H. Atkinson. (Both determined as above by Lloyd.)

3. Geaster Bryantii Berkeley. Plate iii, fig. 10.

Outl. Brit. Fung., 1860, p. 300.—*G. orientalis* Hazsl., *Grev.*, vi, 1877, p. 108.—*G. Kunzei* Wint., in Rabenh. *Krypt. Fl.*, i, 1884, p. 911.

Separated from *G. pectinatus* by the presence of a well-defined collar or ring around the base of the endoperidium immediately above the pedicel.

Distribution.—Britain; Sweden; North America; Australia.

New South Wales: * Hawkesbury River, July, 1912.

The endoperidium of *G. Bryantii*, and less frequently of *G. pectinatus*, is often quite covered with a farinose substance which may be readily rubbed away. This is not of specific value, however, for it may be present or absent in different specimens of the same collection.

4. Geaster ellipticis, n. sp. Plate iii, fig. 11; Pl. vii, fig. 40.

Plants at first globose, submerged, becoming superficial and expanded when 2-3·5 cm. across. Exoperidium split to about the middle into 8-14 subequal, acute rays which are expanded or slightly involute; fleshy layer thin, more or less completely flaking away and leaving exposed the pallid tan fibrous layer; exterior covered with debris held by the adnate mycelial layer, which flakes more or less completely away; base concave.

Endoperidium pedicellate, subglobose or urceolate, 1-2 cm. diam., brown, smooth, shining, apophysis frequently present, base smooth; pedicel short. Peristome sulcate, prominent, conical, elliptical, up to 8 mm. long, sometimes two present on the same plant, concolorous or darker.

Gleba chocolate or almost black; columella wanting. Spores 4·6-8 μ, globose or subglobose; epispore dark brown, moderately and coarsely verrucose, reticulate.

Habitat.—Solitary or in groups on the ground under scrub.

Distribution.—Australia: * Pearson Island, Great Australian Bight, Jan., 1924. Type.

This species resembles the form of *G. pectinatus* known as *G. Schmidelii*, but is separated on account of the conspicuously elliptical peristome.

5. GEASTER HARIOTII Lloyd. Plate iv, fig. 12.
Mycological Notes, 1907, p. 311.

Plants at first globose, submerged, becoming superficial and expanded when up to 5 cm. across. Exoperidium split to about the middle into 7-9 subequal, acute, revolute or expanded rays; fleshy layer umber, becoming rimose; exterior covered with debris held by the adnate mycelial layer; base concave.

Endoperidium subpedicellate or sessile, up to 2 cm. diam., depressed-globose, dark umber, distinctly pitted and roughened but not warted nor tomentose. Peristome sulcate, conical, acute, darker in colour.

Gleba umber; columella not seen. Spores globose, 2·9-4·1 μ; epispore umber, minutely, finely and closely verruculose.

Habitat.—Solitary on the ground.

Distribution.—Spain; Martinique; Porto Rico; Rio de Janeiro; Chile; Brazil; British Honduras; Dutch Guiana; Australia.

New South Wales: * Mummulgum, Dec., 1916.

The species is characterized by the pitted and roughened endoperidium, and especially by the minute, finely verruculose spores. The collection referred to above is placed under this species for it agrees closely in all particulars save that the specimen possesses a shortly pedicellate endoperidium. But as this is a variable character, it is doubtful whether it is of sufficient importance to separate this specimen, especially as the pedicel is such a short one. The minute spores so resemble those of *G. Hariotii* as described and figured by Coker (1924, p. 215) that the writer does not hesitate in determining it. Furthermore, Coker states that there is a collection in the Lloyd herbarium (under *G. Archeri*) from Victoria consisting of a pale form of this species.

†6. GEASTER BERKELEYI Massee.
Ann. Bot. iv, 1891, p. 79.

Plants at first globose, submerged, becoming superficial when expanded and 6-9 cm. across. Exoperidium split to about the middle into 7-9 unequal, acute, expanded or slightly revolute rays; fleshy layer brown, even, slightly rimose; exterior covered with debris held by the adnate, persistent mycelial layer; base concave.

Endoperidium pedicellate, ovate, up to 3 cm. diam., brown, coarsely papillate or granular; pedicel short, 3-5 mm. long. Peristome sulcate, prominent, conical, surrounded by a depressed, smooth, silky zone which is usually lighter in colour.

Gleba umber; columella short, globose. Spores globose, 5-6 μ diam.; epispore umber, acutely warted.

Habitat.—Solitary on the ground under trees.

Distribution.—England; South Australia.

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† The writer has not seen specimens; the description given has been taken from Rea (1922) but rearranged so as to agree with the other descriptions included herein.

The species is separated from *G. pectinatus* by the rough endoperidium, from *G. Hariotii* by the larger spores, and from both by the depressed silky zone around the peristome.

7. GEASTER CAMPESTER Morgan. Plate ii, fig. 1; iii, figs. 13, 14; vii, fig. 41.

American Naturalist, xxi, 1887, p. 1026.—*G. pseudomammosus* P. Henn., *Hedw.*, xxxix, 1900, p. 54.—*G. asper* (Mich.) Lloyd, *Geastreae*, 1902, p. 18.

Plants small, globose, at first submerged, becoming superficial and expanded when up to 4 cm. across. Exoperidium split to about the middle into 7-12 acute, equal rays which are expanded when wet, involute when dry, folding over or under the endoperidium, or sometimes revolute; fleshy layer umber adnate, continuous or rimose; exterior covered with debris held by the closely adnate mycelial layer, becoming partly smooth; base umbilicate.

Endoperidium shortly pedicellate, depressed-globose or subglobose, up to 15 mm. diam., dingy white, tan or bay-brown, finely and closely asperate. Peristome conical, acute, seated on a depressed zone, which may be absent, frequently darker in colour.

Gleba umber; columella clavate, conspicuous. Spores globose, 6-8 μ; epispore chestnut-brown, closely and sparsely verrucose.

Habitat.—Solitary or in groups on the ground.

Distribution.—Hungary; North America; Australia.

South Australia: * Kinchina, July, 1923, June, 1925, Aug. 1925; * Mannum, Apl., 1924; Hallett's Cove, Apl., 1924.

The exoperidium varies in different individuals of *G. campester* from being strongly hygroscopic to a flaccid, almost revolute condition. In fact, Lloyd (1902, p. 18) takes the species in his non-rigidae (non-hygroscopic) section. Coker (1924, p. 216), on the other hand, considers the species to belong to the hygroscopic section, a conclusion borne out by both his and Lloyd's illustrations.

The specific name *asper*, as used by Lloyd, was taken from a publication antedating the starting-point of modern nomenclature, Persoon, 1801, and so cannot be used.

The Australian species placed under the hygroscopic section of the group possessing sulcate peristomes so closely resemble one another as frequently to make separation a difficult matter. The section is usually subdivided according to whether species possess pedicellate endoperidia, but this character is of doubtful value, for specimens of the species included under the pedicellate section are occasionally sessile, and those placed under the sessile section frequently shortly pedicellate.

After extended examination of numerous collections the writer believes separation may be effected as in the key above (p. 75).

8. GEASTER CLELANDII Lloyd. Plate iv, fig. 15.

Mycological Notes, 1918, p. 794.

Plants globose, submerged, becoming superficial and expanded when up to 5 cm. across. Exoperidium split to about the middle into 8-10 acute, equal rays, which are expanded when wet, strongly involute when dry, folding over or under the endoperidium; fleshy layer umber, adnate, continuous, exterior covered with debris held by the adnate mycelial layer; base umbilicate.

Endoperidium shortly pedicellate, depressed-globose, up to 15 mm. diam., umber, coarsely and closely asperate. Peristome conical, acute, seated on a depressed zone, concolorous or darker.

Gleba ferruginous or umber; columella not seen. Spores globose or subglobose, 4·5·5 μ; epispore pallid brown, finely and closely verrucose.

Habitat.—Solitary or in small groups on the ground.

Distribution.—Australia.

Victoria: * Craigie, June, 1917, E. J. Semmens (Det. Lloyd, No. 360, as *G. Smithii*).

Western Australia: * Kalgoorlie, June, 1917, Mrs. A. F. Cleland. Type collection.

The species is separated from *G. campester* chiefly by the smaller spores, and from *G. Smithii* by the slightly larger spores and especially by the asperate endoperidium. The plant closely resembles *G. Drummondii*, but is separated by the smaller spores and pedicellate endoperidium.

9. Geaster Smithii Lloyd. Plate ii, fig. 2; iv, fig. 16.
Geastreae, 1902, p. 21.

Plants small, at first submerged, becoming superficial and expanded when up to 4 cm. across. Exoperidium split to about the middle into 8-9 acute, equal rays, which are expanded when wet, involute when dry, folding in under the endoperidium; fleshy layer adnate, ferruginous, continuous, farinose; exterior covered with debris held by the adnate mycelial layer; base umbilicate.

Endoperidium shortly pedicellate, urceolate or pyriform, up to 15 mm. diam., pallid-tan or chestnut-brown, farinose, smooth, shining, papyraceous. Peristome flattened-conical or acutely conical, seated on a depressed zone, concolorous or darker.

Gleba ferruginous; columella inevident. Spores globose, 3·5-4·2 μ; epispore pallid ferruginous, finely and closely verruculose.

Habitat.—Solitary on the ground.

Distribution.—North America; Australia.

New South Wales: * Parramatta, July, 1912.

South Australia: * Overland Corner, Dec., 1912.

This species is considered by many mycologists to be a synonym of *G. umbilicatus*, but the subhygroscopic exoperidium and especially the smooth, shining, pedicellate endoperidium separate it. The flattened-conical peristome, which is made one of the chief characters of the species by Lloyd, is not of specific value for the same structure is present in occasional specimens of both *G. campester* and *G. Drummondii.*

The specimen from Parramatta exactly resembles the photograph presented by Lloyd. It differs from his description only in that the gleba is ferruginous and not black.

10. Geaster Drummondii Berkeley. Plate iv, figs. 17, 18; vii, fig. 42.

Hooker's *Journal of Botany*, v, 1846, p. 1.—*G. striatulus* Kalchbr. et Cke., *Grev.*, ix, 1880, p. 3.—*G. Schweinfurthii* P. Henn., in Engl. *Bot. Jahrb.*, xiv, 1891, p. 361.—*G. involutus* Mass., *Grev.*, xxi, 1892, p. 3.

Plants small, globose, at first submerged, becoming superficial and expanded when up to 3 cm. across. Exoperidium split to about the middle into 8-10 acute, equal rays, which are expanded when wet, strongly involute when dry, folding over or under the endoperidium; fleshy layer umber, frequently farinose, adnate, continuous; exterior covered with debris held by the adnate mycelial layer, becoming partly smooth; base umbilicate.

Endoperidium sessile or occasionally shortly pedicellate, globose or depressed-globose, up to 10 mm. diam., dingy white or less frequently brown, finely asperate, often becoming smooth with age. Peristome conical, acute or flattened, seated on a depressed zone, which may be wanting, frequently darker in colour.

Gleba ferruginous; columella inevident. Spores globose or subglobose, frequently apiculate, 4·9-6·5 μ; epispore ferruginous, finely and sparsely verrucose.

Habitat.—In small groups on the ground.

Distribution.—Australia; Tasmania.

South Australia: * Encounter Bay, Aug., 1923 (Det. Lloyd, No. 888 as above); * Kinchina, June, 1925.

Victoria: Dimboola, June, 1890, F. M. Reader (Three collections; one determined by Lloyd as *G. striatulus*, another as *G. Drummondii*, the third was in a packet labelled *G. argenteus* Cke.). Herb. Vic. Dept. Agr.

Tasmania: Hobart, L. Rodway. Herb. Rodway, No. 1424.

Individual plants of this species may be sessile or shortly pedicellate; the pedicellate forms closely approach *G. Clelandii*, when the latter species may be separated by the more coarsely asperate endoperidium and smaller spores.

G. Drummondii closely resembles *G. umbilicatus* Fr. and is in fact separated only by the larger spores (those of *G. umbilicatus* being 3·5-4·2 μ). It would appear to replace the latter species in this biological area, for the writer has not seen Australian specimens he would consider to belong to *G. umbilicatus*.

11. GEASTER MINUS (Persoon), n. comb. Plate iv, fig. 23.

Geastrum quadrifidum var. *minus* Pers., *Syn. Meth. Fung.*, 1801, p. 133.—*G. quadrifidum* Nees, *Syst. Pilz. Schw.*, 1817, f. 128.—*G. minimus* Schw., *Syn. Fung. Carol.*, 1822, No. 327.—*Geaster fornicatus* Fr. p.p., *Syst. Myc.*, iii, 1829, p. 12.—*G. marginatus* Vitt., *Mon. Lyc.*, 1842, p. 163.—*G. Cesatii* Rabenh., *Bot. Zeit.*, ix, 1851, p. 628.—*G. granulosus* Fcl., *Enumerat.*, 1860, p. 41.—*G. coronatus* (Schaeff.) Schroet., p.p. *Krypt. Fl. Schw.*, iii, 1889.—*G. coronatus* (Schaeff.) Lloyd, *Geastreae*, 1902, p. 31.—*G. calceus* Lloyd, *Myc. Notes*, 1907, p. 311.—*G. juniperinus* McBr., *Mycologia*, iv, 1912, p. 85.

Plants at first globose, small, submerged, becoming erumpent and expanded when up to 3 cm. across. Exoperidium split to about the middle into 4-8 unequal, acuminate rays, which are commonly recurved or expanded, or may become fornicate by the mycelial layer splitting free from the fibrous layer, which together with the fleshy layer becomes arched (fornicate) but remains attached by the apices of the rays to the mycelial layer, the latter remaining attached to the substratum; fleshy layer brown, rimose, frequently flaking away in patches.

Endoperidium pedicellate, 3-12 mm. diam., obovate, elliptical or depressed-globose, variable in size and shape, pallid-white, tan, or bay-brown, sometimes umber, glabrous, farinose, or coated with closely adnate glistening particles, giving to the whole a glistening appearance; pedicel up to 3 mm. long, frequently with an apical apophysis. Peristome variable, typically conical and fibrillose-fimbriate, frequently silky-fibrillose, sometimes almost indefinite and plane, seated on a definite silky area outlined by a depressed groove, or indefinite when the groove is scarcely apparent or absent.

Gleba ferruginous; columella inevident. Spores globose, 4·5-5·8 μ; epispore fuscous or umber, finely, sparsely and irregularly verrucose.

Habitat.—Solitary, in groups or caespitose on the ground.

Distribution.—France; Austria; Hungary; Sweden; North America; Jamaica; Japan; Ecuador; Australia; New Zealand.

South Australia: * Berri, Jan., 1921; * Beaumont, Adelaide, May, 1922; * Monarto South, July, 1922; * Fullarton, Adelaide, June, 1922; May, 1923; * Pt. Lincoln, May, 1923; * Glen Osmond, June, 1923; * Marble Range, West Coast, June, 1923; * Kinchina, Nov., 1924, June, 1925; * Pearson Island, Great Australian Bight, Jan., 1922; * Mt. Wedge, Eyre's Peninsula, Aug., 1925.

Victoria: Dimboola, June, 1890, F. M. Reader (Herb. Vic. Dept. Agr.).

New Zealand: ** Sandhills, Levin, Wellington, Nov., 1919, S. A. Cunningham; ** Dunedin, Otago, Miss H. K. Dalrymple, May, 1922; ** Ashburton, Canterbury, Aug., 1925, J. C. Neill, D. W. McKenzie.

This is the most variable species of those Australasian Geasters examined by the writer. Specimens vary in size from minute plants 5 mm. across to forms over 4 cm. across. The exoperidium may be revolute (*G. minimus*), fornicate (*G. coronatus*), hygroscopic (*G. arenarius*), or saccate (when the plants resemble small forms of *G. triplex*). The endoperidium may be pedicellate or almost sessile, and may be smooth, covered with minute glistening particles, or with a thick white incrustation (*G. calceus*). The peristome may be plane, conical or obscure, and may be seated on a flattened silky zone outlined by a depressed groove, or the zone may be inevident, the groove in such cases being absent. The peristome may be fibrillose-silky, distinctly fimbriate-lacerate or almost indefinite. The spores, too, vary in size and degree of roughness, and two types may be recognized, one averaging 4·9-5·8 μ, the other 3·5-4·2 μ. The collections from Beaumont, Fullarton and Kinchina above are of the latter type.

Many names have been given these various forms but it is not practicable to separate one from another owing to the difficulty in defining the limits of each. Possibly the form known as *G. arenarius* is worthy of a distinct name, although even with this form plants occur which are difficult to place.

The fornicate and revolute forms have hitherto been considered as distinct species, the former being known as *G. coronatus*, the latter as *G. minimus*; but Coker (1924, p. 206) has shown that the fornicate form is but a condition of the other, for he found all connecting stages growing together.

The name for this species is taken from *Geastrum quadrifidum* var. *minus*, for in his publication Persoon clearly set out the differences between this and *G. fenestriatus* (= *G. fornicatus* Auctt.); see the note under the latter species. Furthermore, the specific name *coronatus* is preoccupied; see below, under *G. limbatus*.

12. GEASTER LIMBATUS Fries. Plate ii, fig. 5; iv, figs. 19-22; vii, fig. 43.

Syst. Myc., iii, 1829, p. 15.—*Geastrum coronatus* Pers. p.p., *Syn. Meth. Fung.*, 1801, p. 132.

Plants at first globose, submerged, becoming superficial and expanded when 3-6 cm. across. Exoperidium split to about the middle into 7-10 unequal, acute rays, which are expanded and revolute, or sometimes partially involute; fleshy layer bay-brown or ferruginous, continuous or rimose, frequently farinose; *exterior covered with debris held by the persistent, adnate mycelial layer*, in old specimens frequently partially flaking away; base concave or plane.

Endoperidium pedicellate, depressed globose, obovate or sub-pyriform, glabrous when old, farinose when young, grey or weathered to umber, up to 1·5 cm. diam. Peristome depressed, acute, fibrillose, surrounded by a pallid or concolorous fibrillose or silky zone.

Gleba chocolate; columella almost obsolete. Spores globose, 4·9-5·4 μ; epispore fuscous, acutely, densely and coarsely warted, opaque.

Habitat.—In small groups on the ground.

Distribution.—Britain; Tyrol; Hungary; North America; East Africa; Australia; New Zealand.

New South Wales: * Murwillumbah, Apl., 1916.

South Australia: Murray Bridge, Apl., 1889, J. G. O. Tepper (Herb. Vic. Dept. Agr.); * Mt. Lofty, July, 1914; * Glen Osmond, 1921; * Adelaide, 1921; * Fullarton, Dec., 1922, Feb., 1923; * Beaumont, May, 1923, Apl., 1924; * Encounter Bay, Jan., 1924; * Kinchina, Nov., 1924, Jan., June, 1925; Hallett's Cove, Apl., 1924.

New Zealand: ** Sandhills, Levin, Wellington, Oct., 1919, E. H. Atkinson; ** Wadestown, Wellington, Apl., 1923, J. C. Neill; ** Ashburton, Canterbury, Aug., 1925, J. C. Neill, D. W. McKenzie; ** Kelburn, Wellington, Nov., 1925, G.H.C.

The plant from this biological region is the same as that referred to *G. limbatus* by nearly all European mycologists, but differs from the plant described by Coker (1924) as occurring in North America, by the somewhat roughened exoperidium and especially by the persistent, universal mycelial layer. His plant has the exterior free or almost free from debris, is attached to the substratum by a central basal mycelial cord and not generally as with our plant. Further, the mycelial layer in the American plant frequently becomes separated from the fibrous layer and assumes a pseudo-fornicate appearance. It is obvious that Coker is dealing with a plant that is not *G. limbatus* Fr. but is either undescribed, or, what is probable, a sub-pedicellate form of *G. triplex*, a supposition strengthened by the epigaean habit.

The definite fibrillose peristome, large and coarsely warted spores and evident pedicel are the characters of *G. limbatus*.

Lloyd has confused *G. limbatus* with *G. rufescens*, for he considers the former is separated from the latter only by the absence of a well-defined pedicel. *G. rufescens* has not been found in this biological region, although Lloyd claims a small form is present; this he has determined as *G. Readeri*. It is evident from a specimen so determined in Dr. Cleland's collections that he has mistaken a small form of *G. limbatus* for *G. Readeri*, which, according to Coker (1924, p. 185), who has examined type collection specimens, is a synonym of *G. velutinus*, a plant widely separated from *G. limbatus*.

13. Geaster velutinus Morgan. Plate v, figs. 26, 27.

Journ. Cin. Soc. Nat. Hist., xviii, 1895, p. 38.— ? *G. javanicus* Lev., *Ann. Sci. Nat.*, v, ser. iii, 1846, p. 161.—? *G. dubius* Berk., *Journ. Linn. Soc.*, xiv, 1875, No. 130.—*Cycloderma ohiensis* Cke., *Grev.*, xi, 1883, p. 95.—*Geaster Readeri* Cke. et Mass., *Grev.*, xvi, 1888, p. 73.—*G. Lloydii* Bres., *Myc. Notes*, 1901, p. 50.

Plants ovate, bluntly pointed, superficial, attached to the substratum by a central basal cord, becoming expanded when 3-6 cm. across. Exoperidium saccate, split to about the middle into 5-8 expanded or revolute, broad, thick, subequal rays which when dry frequently split into two thin fibrous and persistent layers; fleshy layer flesh-coloured, umber and rimose when dry; exterior free from debris, covered with close, brown, felted tomentum; base convex, marked with a prominent umbilical scar.

Endoperidium sessile; globose or depressed-globose, up to 2 cm. diam., brown or pallid-tan, minutely furfuraceous or tomentose, lower portion enclosed by the saccate base of the exoperidium. Peristome small, broadly conical, fibrillose, seated on a depressed silky zone, which may be wanting, concolorous or pallid.

Gleba umber; columella cylindrical; capillitium threads occasionally branched near their apices. Spores globose, 4·1-4·5 μ; epispore fuscous, finely and sparsely echinulate, reticulate.

Habitat.—Epigaean; crowded in small groups on vegetable debris, or frequently on decaying wood on the forest floor.

Distribution.—North America; Cuba; Porto Rico; Brazil; Africa; Gold Coast Colony; Australia; New Zealand.

New South Wales: * Kangaroo Valley, June, 1919.

South Australia: * Kinchina, July, 1923.

New Zealand: ** Weraroa, Wellington, Aug., 1919, G.H.C. (Det. Lloyd as *G. javanicus*); ** Botanical Gardens, Wellington, July, 1922, June, 1925; ** Weraroa, May, 1923, J. C. Neill, (3 collections).

This is the most abundant species in New Zealand, but is apparently rare in Australia. According to Lloyd (*Myc. Notes*, 1907, p. 315), *G. javanicus* Lev. is a dark-coloured form. If so, this name must replace *velutinus*, but in the absence of authentic specimens of *G. javanicus* for examination, the writer is not disposed to make the change. *Cycloderma ohiensis* was based on unopened plants, so the specific name *ohiensis* cannot replace *velutinus*. *G. dubius*, also, was based on unopened plants, and is doubtfully considered a synonym of this species.

As a result of the examination of type collection material, in the herbarium of the New York Botanic Garden, Coker (1924) has shown that *G. Readeri* is also a synonym, and not, as Lloyd (1905) claims, a synonym of *G. rufescens*. Lloyd (1903, p. 155) claims that *G. radicans* Berk. is a fornicate condition of this species, but according to Coker the spores are different, although the plants agree in all other respects, especially in the central rooting base and consequent epigaean habit.

A natural section of the genus consists of those species in which the immature plants are at all stages epigaean. The species are all related, and much confusion has arisen as to the specific characters by which they might be delimited. The writer has found that separation is possible as in the above key (page 75).

In addition, *G. mirabilis*, *G. subiculosus* and *G. velutinus* are further characterized in that they grow on a dense mycelial subiculum; this is not so apparent with *G. velutinus*.

14. Geaster mirabilis Montagne. Plate v, fig. 28.

Ann. Sci. Nat., iv, ser. iii, 1855, No. 595.—*G. papyraceus* Berk. et Curt., *Proc. Am. Acad. Arts and Sci.*, iv, 1858, p. 124.—*G. lignicola* Berk., *Journ. Linn. Soc. Bot.*, xviii, 1881, p. 386.—*G. caespitosus* Lloyd, *Myc. Notes*, 1907, p. 315.

Plants, small, subglobose, or obovate, umbonate, superficial, attached by a central basal cord, becoming tardily expanded when up to 2 cm. across. Exoperidium saccate, split to about the middle into 5-7 broad, bluntly pointed rays; fleshy layer flesh-colour, drying bay-brown, continuous, adnate; exterior free from debris, brown, strigose-tomentose; base convex, with a prominent basal umbilical scar.

Endoperidium sessile, subglobose, pallid-tan, finely tomentose or glabrous, lower third enclosed by the saccate base of the exoperidium. Peristome conical, silky, fibrillose, concolorous or darker, frequently seated on a depressed zone.

Gleba umber; columella inevident. Spores globose, 3-4 μ; epispore fuscous, minutely and closely verruculose.

Habitat.—Solitary or more frequently densely caespitose upon a pallid mycelial subiculum on decaying wood or other vegetable debris on the forest floor; epigaean.

Distribution.—North America; Jamaica; Brazil; Cuba; Africa; Ceylon; Bonin Is.; Japan; Australia.

Queensland: Rockingham. Type of *G. lignicola*, in Kew Herb.

The writer has not seen Australian specimens, and so has drawn up the description of this species from North American material kindly donated by Dr. Coker (No. 7331).

Coker (1924, p. 190) has examined the type material of *G. lignicola* at Kew and considers it to be the same as *G. mirabilis*, for it appears to differ only in that the exterior of the exoperidium is nearly smooth, and not so distinctly strigose-tomentose as the North American specimens.

The species is separated from *G. velutinus* by the small size, caespitose habit and strigose-tomentose exterior. The spores are slightly larger but are more finely marked.

15. GEASTER SUBICULOSUS Cooke and Massee.
Grevillea, xvi, 1887, p. 16.

Coker (1924), who has examined the types at Kew, states:

"The best specimen shows a spore sac [endoperidium] about 7 mm. thick, dark brown; peristome not outlined by a groove or ridge but paler and fibrous. Surface of buttons [immature plants] minutely spongy, of older plants nearly glabrous. Largest button 1·1 cm. thick. Subiculum white, membranous. Spores spherical, practically smooth, some finely dotted, 3-3·8 μ".

He refers to this species a collection from Jamaica in which the spores are smooth, globose, 2-3 μ.

Habitat.—Crowded on a white mycelial subiculum on the surface of rotting vegetable debris; epigaean.

Distribution.—Jamaica (?); Australia.

Australia: Trinity Bay. Type in Kew Herbarium. * ? New South Wales: Forbes, Aug., 1915.

The writer would refer a specimen in Dr. Cleland's possession to this species. The spores are 2·9-3·7 μ, globose, and delicately verruculose under the oil immersion, smooth under a lower power. The exterior is buff-coloured and spongy-tomentose; the peristome is seated on a depressed area and is scarcely fibrillose and almost plane.

The species is characterized by the almost smooth spores, a character not possessed by any other Australasian species. Lloyd (1905, p. 20) considers it to be a form of *G. mirabilis*.

16. GEASTER SACCATUS Fries. Plate vii, fig. 44.
Syst. Myc., iii, 1829, p. 16.

Plants superficial, ovate, pointed or umbonate, attached by a basal mycelial cord, becoming expanded when 2-3 cm. across. Exoperidium saccate, split to about the middle into 5-9 pliable, thin, expanded or revolute, equal, acute rays; fleshy layer brown, adnate, frequently rimose; exterior smooth, free from debris; base concave or plane, sometimes convex, with a prominent umbilical scar.

Endoperidium sessile, up to 1·5 cm. diam., globose, glabrous, brown, partially enclosed by the saccate base of the exoperidium. Peristome fibrillose, almost plane, concolorous or pallid, even, seated on a small depressed silky zone.

Gleba umber; columella indistinct. Spores globose, 2·3-3·7 μ; epispore umber, finely and closely verruculose, reticulate.

Habitat.—Solitary or in small groups on the ground; epigaean.

Distribution.—Britain; Europe; North and South America; Bahamas; Jamaica; Australia; Tasmania.

New South Wales: * National Park, July, 1916 (Det. Lloyd, No. 358, as above); * Junee, Oct., 1917 (Det. Lloyd, No. 472, as *G. arenarius*).

Victoria: Smedley Park, Melbourne, Apl., 1884, F. M. Reader; Myrniong, 1900, D. McAlpine. (Both in Herb. Vic. Dept. Agr.)

Tasmania: Hobart, L. Rodway (Herb. Rodway, No. 1422).

Opinions differ as to what plant Fries described as *G. saccatus*, and specimens in different herbaria may be found under different names. For example one of Dr. Cleland's collections determined by Lloyd as *G. arenarius*, the writer has placed under *G. saccatus*; others named by Lloyd as *G. saccatus* the writer has placed under *G. triplex*, *G. australis* and *G. minus* respectively.

The writer would follow certain European mycologists in considering the species to be characterized by the fibrillose peristome, and exoperidium externally free from debris; and in addition would add the presence of a prominent basal umbilical scar (showing the plant to be epigaean) and spores 2·3-3·7 μ in diameter. As so defined the species would appear to have a sparse though wide distribution. Certain plants approach *G. fimbriatus* in the possession of a less definite peristome and tendency for the mycelial layer to hold debris upon the exterior of the exoperidium.

17. GEASTER TRIPLEX Junghuhn. Plate ii, figs. 3, 4; v, figs. 29-31; vi, fig. 32; vii, fig. 45.

Tijdschr., vii, 1840, p. 287.—*G. lageniformis* Vitt., *Mon. Lyc.*, 1842, p. 160.—*G. Archeri* Berk., *Fl. Tas.*, ii, 1860, p. 264.—*G. Michelianus* W. G. Sm., *Gard. Chron.*, 1873, p. 608.—*G. Kalchbrenneri* Hazsl., *Verh. K. K. Zool. Bot. Ges. Wien*, 1876, p. 76.—*G. vittatus* Kalchbr., *Ung. Akad. d. d. Wiss.*, xvii, 1884, p. 10.—*G. coriaceus* Col., *Trans. N. Z. Inst.*, xxii, 1890, p. 451.—*G. Englerianus* P. Henn., Engl. *Bot. Jahrb.*, xiv, 1891, p. 361.—*G. Morganii* Lloyd, *Myc. Notes*, 1901, p. 80.—*G. violaceus* Lloyd, *Myc. Notes*, 1907, p. 310.

Plants superficial, ovate, pointed, becoming expanded when 2-12 cm. across. Exoperidium split to about the middle into 5-8 equal, narrowly acuminate rays, which are expanded or revolute; fleshy layer umber, rimose, frequently partially flaking away, sometimes a small portion persisting as a small collar around the base of the endoperidium; exterior free from debris, bay-brown or tan-coloured, glabrous, usually marked with numerous longitudinal striae; base plane, with a prominent umbilical scar.

Endoperidium sessile, 0·5-2·5 cm. diam., depressed-globose or almost pulvinate, bay-brown or umber, glabrous, finely pitted or smooth, membranous. Peristome fibrillose, mammose, seated on a broad, depressed, silky, pallid zone which is usually outlined by an upraised margin.

Gleba ferruginous to umber; columella clavate or indistinct. Spores globose, 4·1-4·9 μ diam.; epispore almost black, finely and closely verrucose, reticulate.

Habitat.—In groups on decaying vegetable debris; epigaean.

Distribution.—Britain; Europe; North and South America; Australia; Tasmania; New Zealand.

Victoria: Smedley Park, Melbourne, Apl., 1884, F. M. Reader (Herb. Vic. Dept. Agr.).

New South Wales: * Milson Island, Hawkesbury River, July, 1912 (Det. Lloyd, No. 359, as above); * Terrigal, June, 1914; * Neutral Bay, Sydney, June, 1914 (3 coll.); * Dorrigo, Jan., 1918 (Immature plants); * twenty miles north of Baradine, Oct., 1918; * National Park, May, 1919 (2 coll.).

South Australia: * Overland Corner, Dec., 1912.

Lord Howe Island: * July, 1911, W. W. Watts.

Tasmania: Hobart, L. Rodway (Herb. Rodway, No. 1423).

New Zealand: ** Weraroa, Wellington, Aug., 1919, G.H.C. (det. Lloyd as *G. Englerianus*), (2 coll), May, 1923, J. C. Neill; ** Dunedin, Otago, May, 1922, Miss H. K. Dalrymple; ** Whakatikei Forest Reserve, Wellington, June, 1923, J. C. Neill.

The species is characterized by the acuminate apices of the expanded rays, and glabrous, usually striate exterior of the exoperidium, the base of which is marked with a prominent umbilical scar. In typical plants the peristome is very characteristic, the large depressed silky zone surrounding the large, fimbriate-fibrillose mouth readily separating it from *G. saccatus*; but with the small forms the peristome characters merge with those of the latter, in which case separation is possible only upon the larger, more coarsely verrucose, very dark spores of *G. triplex*.

G. triplex closely resembles *G. australis*, but may be separated by the smaller spores, long pointed apex of the immature plant, and darker colour of the endoperidium.

G. Archeri was described as a species possessing a sulcate mouth; Lloyd (1902, p. 20), who first discussed it under the name *G. Morganii*, which he later (1905) showed was a synonym, noted its resemblance to *G. lageniformis* (= *G. triplex*), but claimed it differed in the presence of the sulcate mouth. Later (1905, p. 19) he stated it was *G. saccatus* in all particulars save the indefinite sulcate mouth. Coker (1924) described the peristome (of *G. Morganii*) as being rather vaguely outlined, consisting of a narrowly conical papilla (typically) with the sides crumpled toward the tip or almost all over, forming a pseudo-sulcate peristome with lacerated tip. He considered the species to be related to *G. triplex*, and claimed on account of several minor characters (of no specific import) that *G. Morganii* was distinct from *G. Archeri*. The writer has examined specimens of a dozen plants collected within a radius of 30 cm. (Whakatikei Forest Reserve). The major number are *G. triplex*, but four might be considered as typical specimens of *G. Archeri*, possessing the same pseudo-sulcate peristome. Thus as both forms occur in the same collection (and attached to the same mycelial mass) it is obvious that *G. Archeri* is but a condition of *G. triplex*, in which the normally fibrillose peristome has become accidentally pleated.

G. vittatus was based on plants possessing longitudinal striae on the exterior of the exoperidium. As this is a condition common to plants both of *G. triplex* and *G. australis*, it is obvious that it cannot be considered of specific value.

G. Englerianus was erected on a dark-coloured form, a character of no specific value, for both light and dark coloured plants are frequent in the same collection.

G. violaceus was erected on the purple colour of the endoperidium. In one collection from Australia, one specimen has the endoperidium a dull purple, the other being brown; both are identical in all other respects, thus showing of what slight value colour is as a specific character.

G. lageniformis is a form with a somewhat larger and more silky zone surrounding the peristome, and rays which are thinner and more acute than the typical form of *G. triplex*; in all other respects it is identical.

18. GEASTER AUSTRALIS Berkeley. Plate vi, fig. 33; vii. fig. 46.
Fl. Tas., ii, 1860, p. 265.

Plants superficial, at first ovate and acuminate, becoming expanded when up to 7 cm. across. Exoperidium saccate, split to about the middle into 6-8 broad, equal, acuminate rays, which are tardily expanded or with the tips revolute; fleshy layer bay-brown or chestnut-brown, adnate, continuous when fresh, becoming rimose; exterior free or partially free from debris, ochraceous, glabrous; base plane, convex or occasionally umbilicate, marked with a prominent umbilical scar.

Endoperidium sessile, up to 2 cm. diam., ochraceous or tan-coloured, glabrous, smooth. Peristome fibrillose, mammose, seated on a broad, silky, slightly depressed, concolorous zone, which is occasionally outlined by a slightly raised margin.

Gleba ferruginous; columella inevident. Spores globose, 7·4-8·3 μ; epispore tinted, finely and sparsely verrucose-echinulate.

Habitat.—In small groups on the ground; epigaean.

Distribution.—Australia; Tasmania.

Victoria: Smedley Park, Melbourne, Apl., 1884, F. M. Reader; Wandin, Nov., 1915, C. C. Brittlebank. (Both in Herb. Vic. Dept. Agr.).

South Australia: Murray Bridge, Apl., 1889, J. G. O. Tepper (Herb. Vic. Dept. Agr.); * National Park, Aug., 1921 (doubtfully det. by Lloyd, No. 779, as *G. simulans*), Sept., 1922; * Adelaide, 1924 (immature plants); * F. R. Zeitz coll.

New South Wales: * Bumberry, Sept., 1916 (det. Lloyd, No. 215, as *G. saccatus*); * Manildra, Oct., 1916; * Myall Lakes, May, 1919; * Kendall, Aug., 1919.

This species approaches *G. triplex*, having practically the same habit, peristome characters and smooth exterior to the exoperidium. It differs in the much larger spores and ochraceous endoperidium. As a rule plants are not so free from debris as are those of *G. triplex*, but they have the same epigaean habit, as is evidenced by the presence of the prominent umbilical scar at the base.

19. GEASTER ARENARIUS Lloyd. Plate v, figs. 24, 25.
Geastreae, 1902, p. 28.

This subspecies is a hygroscopic form of *G. minus*, differing only in its shorter pedicel and hygroscopic exoperidium, the rays of which, when dry, fold over or under the endoperidium.

Habitat.—In small groups on sandy soil.

Distribution.—North America; Australia.

New South Wales: * Coolamon, May, 1918 (det. Lloyd, No. 474, as above).

South Australia: * Wirrealpa, Aug., 1921; * Monarto South, Sept., 1921; * Ooldea, Aug., 1922.

In two of these collections the spores are the same size as the types, being 3·2-3·8 μ; in the others they are the size of the typical form of *G. minus*, 4·5-5·8μ. This variation also occurs with *G. minus*, for in many collections the spores are smaller, being the same size as those of the type of *G. arenarius*. It has been considered inadvisable to separate these smaller spored forms, for they are identical in all other particulars with the larger spored forms.

20. GEASTER FENESTRIATUS (Persoon), n. comb. Plate vi, figs. 34, 35.

Geastrum quadrifidum var. *fenestriatum* Pers., *Syn. Meth. Fung.*, 1801, p. 133.—*G. quadrifidum* DC., p.p., *Fl. Fr.*, ii, 1815, p. 267.—*Geaster fornicatus* Fr., p.p., *Syst. Myc.*, iii, 1829, p. 12.—*G. fenestriatus* (Batsch) Lloyd, *Myc. Notes*, 1901, p. 70.—*G. marchicus* P. Henn., *Nat. Pflanzenfam.*, I**, 1901, p. 321.—*G. fornicatus* (Huds.) Fr. Auctt.

Plants globose, at first submerged, becoming superficial and expanded when 3-6 cm. across. Exoperidium split to about the middle into 4-5 rays; the outer (mycelial) layer remaining as a hollow cup in the substratum, the inner fibrous and fleshy layers becoming strongly fornicate, attached at tips to the basal cup, rays firm, thick, brown; fleshy layer brown, partly flaking away from old specimens; base strongly convex.

Endoperidium pedicellate, up to 3 cm. diam., depressed-globose, urnulate, with a constricted ring-like apophysis above the pedicel, ferruginous, finely pubescent. Mouth naked, conical or mammiform, tubular, apex fibrillose, or lacerate.

Gleba ferruginous; columella long-elliptical. Spores globose, 4·2-4·9 μ; epispore umber, moderately and finely verrucose, reticulate.

Habitat.—Solitary on vegetable debris on the ground.

Distribution.—Britain; Hungary; Russia; North America; Mauritius; Algeria; South Africa; Hawaii; Australia.

South Australia: * Pearson Island, Great Australian Bight, Jan., 1923 (2 collections); * Overland Corner, Dec., 1912.

This species is characterized by the fornicate exoperidium, and is on this account readily recognized, being liable to confusion (in this particular) only with *G. minus* and *G. radicans*, but is separated from these two by the naked mouth. This species has in Europe regularly been confused with *G. minus*; certain mycologists refer it to *G. fornicatus* (Huds.) Fr., a name which is untenable, for as Lloyd has frequently and freely pointed out, Fries included both this and *G. minus* in his species, extending his description and citations to cover both. Persoon, however, clearly recognized the differences between the two, for he separated the species discussed above as *Geastrum quadrifidum* var. *fenestriatum*, the other as *G. quadrifidum* var. *minus*. His varietal names are therefore used for the two species under discussion.

Occasionally plants do not become fornicate, but remain in the expanded condition; in such cases the naked mouth serves to characterize them.

GEASTER RUFESCENS (Persoon) Fries.

Syst. Myc., iii, 1829, p. 18.

Lloyd (1905, p. 22) claims that a small form of this species, *G. Readeri*, is present in Australia, but the writer believes he is confusing this with a small form of *G. limbatus*, for one collection so determined is *G. limbatus*. As has been shown, *G. Readeri* is a synonym of *G. velutinus*, a plant widely separated from *G. rufescens*.

21. GEASTER FIMBRIATUS Fries. Plate vi, fig. 36.

Syst. Myc., iii, 1829, p. 16.—*G. tunicatus* Vitt., *Mon. Lyc.*, 1842, p. 118.

Plants globose, submerged, becoming expanded when up to 3 cm. across. Exoperidium saccate, split to about the middle into 6-8 unequal, flaccid, bluntly pointed rays which are tardily expanded or with the tips only revolute; fleshy

layer bay-brown or umber-brown, continuous, adnate; exterior wholly covered with debris held by the adnate mycelial layer, which may partially flake away upon weathering; base convex, plane or concave.

Endoperidium sessile, 0·5-1 cm. diam., depressed-globose, dingy-white to umber-brown, glabrous, smooth. Mouth either an indeterminate aperture with fibrous and lacerated margin, or defined by a slightly depressed, concolorous or lighter zone; sometimes approaching the fibrillose condition.

Gleba umber; columella inevident. Spores globose, 3·3-4·5 μ; epispore fuscous, closely and finely verrucose, reticulate.

Habitat.—In small groups on the ground; hypogaean.

Distribution.—Britain; Italy; Austria; France; North America; Australia; Tasmania.

Victoria: * Staughton Vale, Brisbane Range, Nov., 1923.

New South Wales: * Manildra, Oct., 1916 (det. Lloyd, No. 213, as *G. saccatus*, "pigmy form").

South Australia: * Mt. Dutton Bay, West Coast, May, 1923; * Fullarton, Adelaide, 1924; * Kinchina, June, Aug., 1925.

The species is characterized by the small size, indefinite mouth and persistent mycelial layer. Occasionally in the same collection are encountered plants with a mouth appearing peristomate and fibrillose. Such plants make delimitation difficult, and with this species more so in that the spores are of two types, certain collections possessing spores 3·3-3·7 μ in diameter, others, apparently identical in all other respects, possessing spores 3·7-4·5 μ. The hypogaean habit is a character which should aid the student in the diagnosis of the species, for those species which extreme forms resemble—*G. saccatus* and *G. triplex*—are epigaean, a character which is made apparent in herbarium specimens by the prominent umbilical scar at the base of the exoperidium, a feature absent from *G. fimbriatus*.

22. GEASTER FLORIFORMIS Vittadini. Plate ii, fig. 5; vi, fig. 37; vii, figs. 38, 47.

Mon. Lyc., 1842, p. 167.—*G. delicatus* Morgan, *Am. Nat.*, xxi, 1887, p. 1028.—*G. hungaricus* Hollos, *Gast. Hung.*, 1903, p. 64.

Plants at first globose, submerged, becoming superficial and expanded when 2-6 cm. across. Exoperidium split to about the middle into 7-12 subequal, narrow, acute rays which are expanded when wet, strongly involute when dry, then folding completely over (rarely under) the endoperidium; fleshy layer adnate, smooth, umber, rimose when old; exterior at first covered with debris held by the closely adnate mycelial layer, soon flaking away and leaving exposed the glabrous, ochraceous or brown fibrous layer; base strongly umbilicate.

Endoperidium up to 1·5 cm. diam., sessile, depressed-globose, minutely furfuraceous, glabrous when old. Mouth naked, indefinite, conical or more frequently plane, irregularly torn and apically fibrillose in old specimens.

Gleba umber; columella small, cylindrical. Spores globose, or subglobose, 5·4-7·4 μ; epispore dark brown, closely and coarsely warted.

Habitat.—In groups on the ground; hypogaean.

Distribution.—Hungary; North America; South Africa; Australia; New Zealand.

Victoria: Dimboola, June, 1890, F. M. Reader; Melbourne, D. McAlpine, 1900. (Both collections in Herb. Vic. Dept. Agr.)

New South Wales: * Bibbenluke, Mar., 1913; * Forbes, Aug., 1915 (det. Lloyd, No. 362, as above).

South Australia: * Port Elliot, Aug., 1918, D. I. Cleland; * Adelaide, July, 1914; * Ooldea, Aug., 1922; * Aldinga Bay, Nov., 1923; * Kinchina, Nov., 1924.

New Zealand: ** Masterton, Wellington, May, 1923; ** Dunedin, Otago, Miss H. K. Dalrymple, May, 1923; ** Ashburton, Canterbury, Aug., 1925, J. C. Neill, D. W. McKenzie.

The species is characterized by the hygroscopic exoperidium, sessile endoperidium and naked, indefinite mouth. The large spores are also a feature, although they are not constant in all collections, for in several the writer has examined they are somewhat smaller than the normal, averaging 5·4-6·5 μ. The mouth does not at any time approach the fibrillose condition, so that even with old specimens there is no difficulty in determining the section to which this species belongs.

23. GEASTER SIMULANS Lloyd. Plate vii, figs. 39, 48.
Lyc. Aus., 1905, p. 17.

Plants globose, submerged, becoming superficial and expanded when up to 4 cm. across. Exoperidium split to about the middle into 7-8 unequal, acute rays, which are expanded when wet, involute when dry, folding over or usually under the endoperidium, sometimes drying partially expanded; fleshy layer thick, adnate, umber, rimose or continuous; exterior at first covered with debris held by the adnate mycelial layer, usually flaking away, leaving exposed the ochraceous or bay-brown fibrous layer; base strongly umbilicate.

Endoperidium sessile, depressed-globose, up to 1·5 cm. diam., glabrous, ochraceous. Mouth a minute, indefinite, plane aperture, lacerate or fibrillose when old, slightly wrinkled or folded.

Gleba ferruginous; columella inevident. Spores globose, 4·5·2 μ; epispore fuscous, finely, evenly and closely verruculose, reticulate.

Habitat.—Solitary or in small groups on the ground.

Distribution.—Australia.

New South Wales: * Manildra, Oct., 1916 (det. Lloyd, No. 218, as above).

South Australia: * Kinchina, Aug., 1925.

The species was erected by Lloyd upon specimens in the Kew Herbarium collected by Drummond at Swan River and labelled by Berkeley *G. hygrometricus*. From Lloyd's illustration one would imagine the species to be a small-spored form of *G. floriformis*, but the specimens examined by the writer, determined as this species by Lloyd, are quite different. The plant is perhaps best separated by its subhygroscopic habit, and by the manner in which the basal portion of the endoperidium becomes arched and carries upwards the endoperidium, which appears as if seated on a broad, short pedicel. The thick rays of the exoperidium and the small spores, with their fine and even markings, are also characteristic. Were it not for the hygroscopic habit one would refer it to *G. rufescens*, for the mouth characters somewhat resemble those of this species as now defined. In fact the plant would appear to be intermediate between *G. rufescens* and *G. floriformis*.

Excluded Species.

a. Geaster affinis Col., *Trans. N.Z. Inst.*, xvi, 1883, p. 362.—This is probably a synonym of *G. triplex* or *G. velutinus*, but on account of the poor description impossible to place. No specimens are known.

b. Geaster argentatus Cooke and Massee.—The writer has been unable to locate the description of this species. Coker (1924) states there are specimens so labelled in the Herbarium of the New York Botanic Garden.

c. Geaster coronatus Col., *Trans. N.Z. Inst.*, xvi, 1883, p. 362.—The species is probably a synonym of *G. triplex*, but no specimens are known, so the point cannot be settled. In any case the name is preoccupied.

d. Geaster argenteus Cooke, *Grev.*, xvii, 1889, p. 75.—This species has been recorded from Australia, but it is probable this is an error, for specimens so labelled at Kew are, according to Coker (1924, p. 194), apparently specimens of *G. Drummondii.*

e. Geaster hygrometricus (Pers.) Fr., *Syst. Myc.*, iii, 1829, p. 19.—According to Lloyd (1905) there are no authentic specimens of this species from Australia in the herbaria of Europe. Probably the record was based on the plants at Kew upon which Lloyd erected *G. simulans*, for these were labelled *G. hygrometricus.*

f. Geaster lugubris Kalchbr., *Ungar. Akad. d.d. Wiss.*, xiii, 1884, p. 10.—This is a synonym of *G. mammosus* Fr., a species which is not known to occur in this biological region.

g. Geaster pusillus Fr., *Pl. Preiss.*, ii, 1847, p. 139.—Lloyd (1905, p. 23) states: "No type exists and no one knows anything about it".

h. Cycloderma platyspora Cke. et Mass., *Grev.*, xvi, 1888, p. 74.—This was based on an unopened *Geaster*, probably *G. velutinus.*

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EXPLANATION OF PLATES II-VII.

Plate ii.

Fig. 1. Sulcate peristome of *Geaster campester.* × 2.
Fig. 2. Sulcate peristome of *Geaster Smithii.* × 2.
Fig. 3. Fibrillose peristome of *Geaster triplex.* × 2.
Fig. 4. Fibrillose peristome of *G. triplex* (form *lageniformis*). × 2.
Fig. 5. Fibrillose peristome of *G. limbatus.* × 2. New Zealand form with farinose endoperidium.
Fig. 6. Indefinite mouth of *G. floriformis.* × 2.

Plate iii.

Fig. 7. *G. pectinatus.* Natural size.
Fig. 8. *G. pectinatus.* Natural size. Small form known as *G. Schmidelii.* The two plants on the left could be labelled *G. Bryantii.*
Fig. 9. *G. plicatus.* Natural size.
Fig. 10. *G. Bryantii.* Natural size. Note the farinose covering over the exterior of the endoperidium.
Fig. 11. *G. ellipticis.* Natural size. Typical peristome is shown on the plant third from the left, on the right is a plant with two peristomes.
Fig. 13. *G. campester.* Natural size. Note the different types of peristomes.
Fig. 14. *G. campester.* × 3/2. Showing the asperate endoperidium.

Plate iv.

Fig. 12. *G. Hariotii.* Natural size.
Fig. 15. *G. Clelandii.* × 3/2. Plant on the right shows umbilicate base; note the asperate endoperidium.

Fig. 16. *G. Smithii.* Natural size. Note the glabrous and polished endoperidium, and the sub-hygroscopic exoperidium.

Fig. 17. *G. Drummondii.* Natural size. Expanded plant on the left. Note the glabrous nature of the endoperidium.

Fig. 18. *G. Drummondii.* Natural size. Note the regular nature of the striae of the peristome.

Fig. 19. *G. limbatus.* Natural size. Common form most frequently collected in Australia.

Fig. 20. *Geaster limbatus.* Natural size. A form not uncommon in New Zealand. This has been determined by Lloyd as *G. rufescens.*

Fig. 21. *G. limbatus.* Natural size. A form found in New Zealand, in which the endoperidium is covered with glistening particles.

Fig. 22. *G. limbatus.* Natural size. The Australian form determined by Lloyd as *G. Readeri.*

Fig. 23. *G. minus.* Natural size. The form as it commonly grows.

Plate v.

Fig. 24. *Geaster arenarius.* Natural size. Note the hygroscopic exoperidium, the only character separating it from *G. minus.*

Fig. 25. *G. arenarius.* × 2. Peristome enlarged to show its fibrillose-fimbriate nature.

Fig. 26. *G. velutinus.* Natural size. Note the different appearance the plant takes as it becomes weathered. Typical form in the centre.

Fig. 27. *G. velutinus.* Natural size. Exterior of the exoperidium showing its tomentose nature, and on the plant on the left the prominent umbilical scar.

Fig. 28. *G. mirabilis.* × 2. Plants from Dr. Coker, U.S.A., growing on a mycelial subiculum on rotting wood. Immature plant on the left.

Fig. 29. *G. triplex.* × 1/2. Expanded plant; note the characteristic peristome and acuminate apices of the rays.

Fig. 30. *G. triplex.* × 1/2. Exterior of the exoperidium, showing its glabrous nature, longitudinal striae, and the umbilical scar.

Fig. 31. *G. triplex.* Natural size. Unexpanded plant showing the glabrous exterior and the acuminate apex.

Plate vi.

Fig. 32. *Geaster triplex.* × 2. The form known as *G. Archeri*, showing the pseudo-sulcate peristome.

Fig. 33. *G. australis.* Natural size. Immature plant on the left. Note the light colour of the glabrous endoperidium.

Fig. 34. *G. fenestriatus.* Natural size. Note the fornicate nature of the plants on the right; on the left the plant has not assumed this condition.

Fig. 35. *G. fenestriatus.* × 2/3. This photo shows the cup at the base formed of the mycelial layer and the arched fibrillose layer from which the fleshy layer has partially flaked away, portion forming a collar around the base of the endoperidium.

Fig. 36. *G. fimbriatus.* × 2. The indefinite character of the mouth is well shown.

Fig. 37. *G. floriformis.* Natural size. Hygroscopic plants; the one on the right is partially expanded.

Plate vii.

Fig. 38. *G. floriformis.* Natural size. The plant on the left shows the umbilicate base, the one on the right the indefinite mouth.

Fig. 39. *G. simulans.* Natural size. Central plant shows the umbilicate base; the one on the right the indefinite mouth.

Fig. 40. Spores of *G. ellipticis.*

Fig. 41. Spores of *G. campester.*

Fig. 42. Spores of *G. Drummondii.*

Fig. 43. Spores of *G. limbatus.*

Fig. 44. Spores of *G. saccatus.*

Fig. 45. Spores of *G. triplex.*

Fig. 46. Spores of *G. australis.*

Fig. 47. Spores of *G. floriformis.*

Fig. 48. Spores of *G. simulans.*

All spores magnified 1,050 diameters.

AN ECOLOGICAL STUDY OF THE FLORA OF MOUNT WILSON.

Part iii. The Vegetation of the Valleys.

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(Plates viii-x, and six Text-figures.)

[Read 28th April, 1926.]

Contents.

Introduction.

In Part I of this series of Memoirs (1924) on the Vegetation of Mount Wilson it was pointed out (p. 481) that the region under study is divisible into three physiographic areas, namely, the basalt-capped hills, the sandstone plateau, and the sandstone valleys; and, while it is realized that the classification of plant communities should depend upon the characters of the vegetation itself rather than upon the habitat, it has proved most convenient, so far as work in the field is concerned, to study these areas one at a time, and finally to co-ordinate the results so obtained. Consequently, Part I dealt with the plant-covering of the basalt caps; Part II comprised a study of the *Eucalyptus* Forests of the sandstone plateau; and the present paper embodies an inquiry into the vegetation of the valleys, which, as is apparent from the map in Part I (Plate lvii), frequently intersect the Mount Wilson Plateau.

We desire to express our indebtedness to Mr. M. B. Welch, B.Sc., A.I.C., and Mr. O. D. Evans for kindly identifying several of the Rain-Forest types referred to in this paper; to Mr. W. F. Jackson, B.A., LL.B., for allowing us to reproduce one of his photographs; to the Misses Webb, Thompson, Nichols and McFadyen, Third Year Students in Botany, who made the topographical diagrams from data supplied by us.

THE VEGETATION OF THE VALLEYS.

Owing to the amount of erosion and denudation by weather and river-action which has taken place throughout a great expanse of time, the area under review has been much dissected; and instead of a flat tract covered with a uniform and continuous basalt sheet, we find isolated conical or dome-shaped hills, raised above the general level of the surrounding sandstone plateau, and separated by deep river-valleys with slopes which, especially in the lower levels, are more or less precipitous. The crown and upper slopes of these hills are covered to varying

Text-figure 1. General sketch showing the broken topography of the Mount Wilson area.
Between Mt. Irvine and Mt. Wilson, looking south.

depths with the decomposed basalt, which is as a rule thickest at the crown, thinning out down the slope. On all the exposed parts, *i.e.*, areas with a westerly, north-westerly or south-westerly aspect, the basalt has weathered but little; on all other aspects, however, favourable conditions for weathering are found, and there is a rich soil formed by the decomposition of the lava. The lower half of the slopes, of which the upper half is covered with basaltic soil, is composed of sandstone; this has weathered, and, if the aspect is east, south-east, or south, is mixed with large quantities of decomposing humus, forming a favourable soil for the Rain-Forest. On such slopes the vegetation is protected always from the westerly winds, scorching and arid in summer, cold and desiccating in winter. The Indo-Malayan types which constitute the main components of the Rain-Forest at Mount Wilson, are absolutely incapable of resisting the injurious results of a westerly exposure: on such a slope we find the typical association of the sandstone, dominated by *Eucalyptus piperita* or *E. haemastoma* var. *micrantha*, and with the characteristic shrub strata which have already been described in Part II (1925).

The occurrence of each of the associations in the valleys may now be considered more in detail.

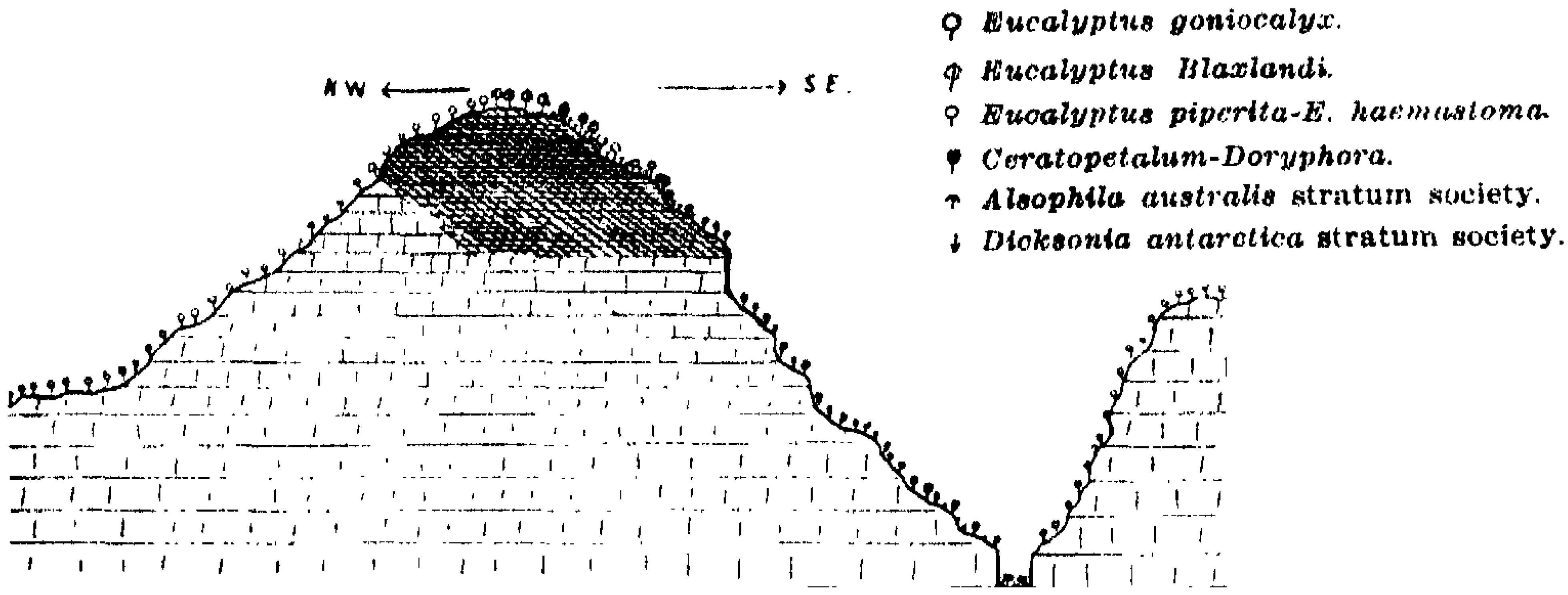
THE CERATOPETALUM-DORYPHORA ASSOCIATION.

Structure and Distribution.

This Forest is found on the basalt slopes with a south to south-east exposure, and in the deep river-valleys cut out of the sandstone. Its presence in the former habitat was dealt with in Part I, so that it remains for us to discuss its occurrence on the sandstone in the present paper.

Every gully and cutting into the Mount Wilson Plateau has a belt of the *Ceratopetalum-Doryphora* Forest of varying width and extent, primarily determined by the aspect of the valley, and its protection from the westerly winds.

In many of the deeper gullies, which frequently have rugged and precipitous slopes, the association experiences practically optimum conditions of shelter and moisture, so that its development is only slightly less luxuriant than on the sheltered basalt slopes: in other valleys the conditions required are found only in the bottom of narrow ravines through which the stream flows, and whose precipitous walls (50 to 200 feet high) furnish the shelter so essential to this mesophytic community. On exposed slopes there is a wide belt of *Eucalyptus* Forest separating the *Ceratopetalum-Doryphora* association in the valley bottom from the same association on the basalt cap above; but on the more favourable slopes (*i.e.*, with south or south-east aspect) there is no discontinuity, and the Rain-Forest of the upper basalt-covered slopes is continuous with that on the lower sandstone slopes and with that in the valleys.

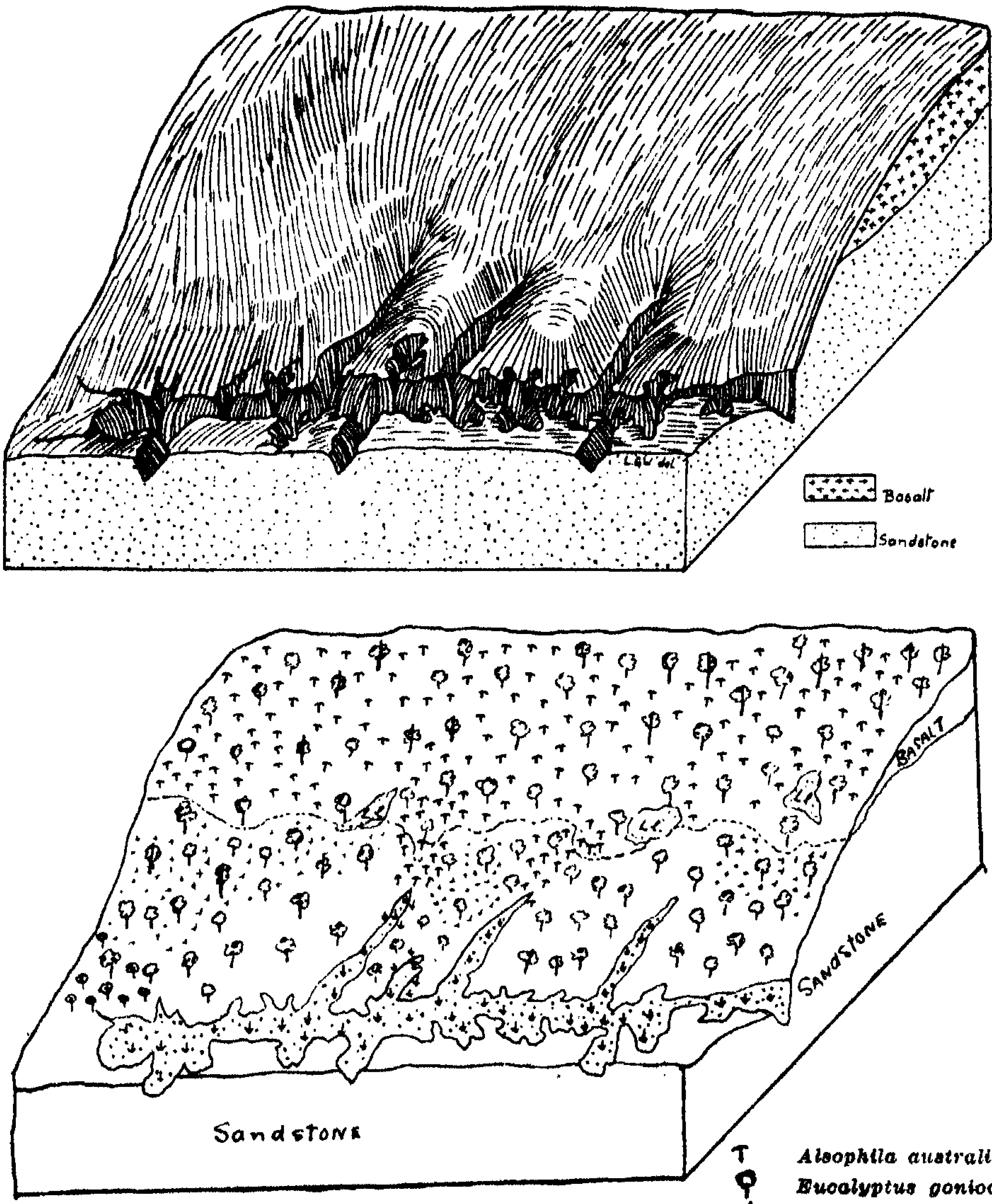


Text-figure 2. Diagrammatic section across a portion of the Mt. Wilson area, showing the relative distribution of the chief plant communities in relation to the basalt, sandstone and exposure. The cross-hatched area is the basaltic cap upon the sandstone. On the north-west slopes the *E. piperita-E. haemastoma* association is found, on the south-east slopes, the associations are the *E. goniocalyx-E. Blaxlandi*, the *Eucalyptus-Doryphora* ecotone and the *Ceratopetalum-Doryphora* covering the lower basalt area and the entire sandstone portion of the slope.

A most interesting physiographic feature which has a striking influence upon the distribution of the *Ceratopetalum-Doryphora* Forest is the occurrence of troughs or erosion-channels of various sizes and depths on the slopes of the larger valleys. Although these are common on the sandstone they are comparatively rare on the basalt. This is probably owing to the more gradual slope and the lack of surface-drainage on the basalt; at any rate the effect of erosion by the surface water during heavy precipitations appears to be much greater on the sandstone than on the basalt, and the drainage-channels with every heavy rainfall are being cut deeper and deeper into the slope.

The effect of exposure is clearly illustrated by the flora which develops in these erosion-channels: on exposed sandstone slopes having westerly, north-westerly, or south-westerly aspects they are occupied by *Alsophila* or *Callicoma* societies in the *Eucalyptus goniocalyx* consociation, as will be described subsequently; on slopes with a north-east exposure, however, the deeper channels are colonized at their lower extremities by the *Eucalyptus-Doryphora* ecotone or even

the *Ceratopetalum-Doryphora* association itself. *Ceratopetalum*, unlike *Doryphora*, seldom passes beyond the limits of its association; the latter, however, with *Acacia elata* and *A. melanoxylon*, is conspicuous in the ecotone region, where also *Dicksonia antarctica*, *Todea barbara* and *Alsophila australis* form dense tree-



Text-figure 3. Diagrammatic sketch of a north-east slope showing its topography and the distribution of the chief plant communities.

fern societies with overlapping fronds. The vegetation of some of these channels consists essentially of the *Eucalyptus goniocalyx* consociation with the *Alsophila* stratum-society and an occasional *Doryphora* and *Acacia*; but all stages between this and the typical *Eucalyptus-Doryphora* ecotone are found, until in the lower parts of some we find the *Ceratopetalum-Doryphora* association itself, only differing in the absence of such sciophytes as *Blechnum capense*, *B. Patersoni* and *Drimys dipetala*, which prefer deeper shade and higher humidity than is obtained in this habitat.

There is considerable probability that in these erosion-channels, which are in various stages of development, we are witnessing the gradual upward migration of the Rain-Forest. The vanguard consists of tree-ferns, which in places actually merge into the *Alsophila* stratum-society of the *Eucalyptus goniocalyx-E. Blaxlandi* association of the basalt on the higher part of the slope, so that a continuous strip of tree-ferns is seen extending the whole length of the drainage-channel; other components follow, giving rise to the *Eucalyptus-Doryphora* ecotone; after which there seems no doubt that the *Eucalyptus-Doryphora* association will follow with its typical structure and composition.

The accompanying diagrammatic sketch (Text-fig. 3) will serve to elucidate the distribution of the communities on a north-easterly slope where this succession is found to occur.

Comparison of the Structure and Composition of the Rain-Forest of the Sandstone and Basalt.

South or south-east slopes represent the most favourable habitat for the development of the *Ceratopetalum-Doryphora* Forest, which is here not confined to the troughs, but densely covers the entire surface of the slopes from the basalt above to the valley-bottom. It is on these slopes that the Rain-Forest reaches its maximum development, and obtains optimum environmental conditions. There is no discontinuity in the association-type as we pass from the basalt to the sandstone; the *Ceratopetalum-Doryphora* association therefore exists in two edaphic habitats, namely, the basaltic soil and the Hawkesbury Sandstone; but although the dominants and, therefore, the general physiognomy, are unchanged, certain important and striking differences occur in the composition of the subordinates.

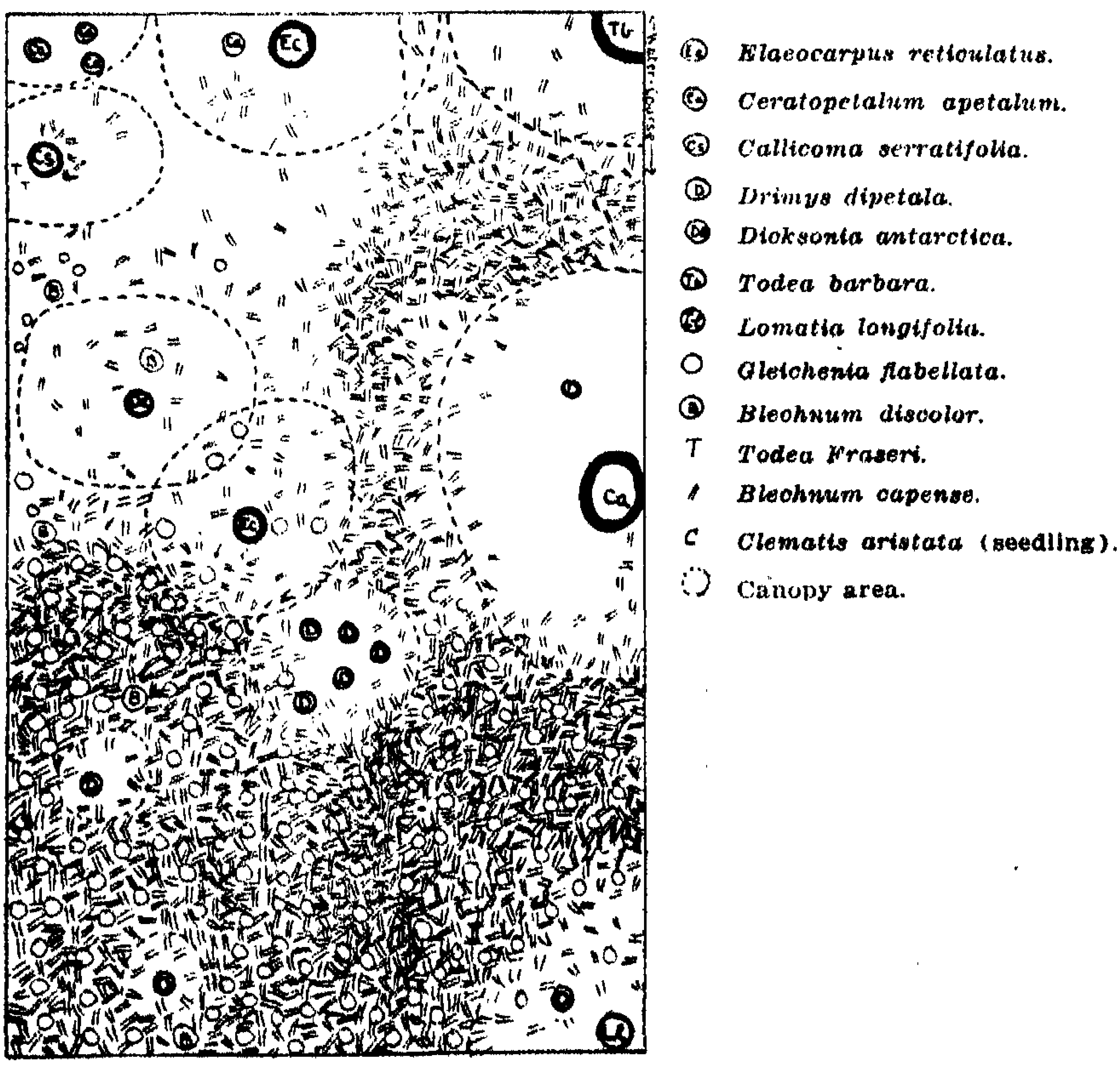
Where the sandstone-gully Rain-Forest is continuous with that of the basalt, the volcanic soil is carried down as a talus for some distance over the sandstone. This, possibly combined with leaching of soluble constituents, results in an ecotone of variable width being established between the two typical expressions of the *Ceratopetalum-Doryphora* Forest.

For the present, however, we shall concern ourselves with contrasting the typical expression of the *Ceratopetalum-Doryphora* Forest of the sandstone with that of the basalt.

In the tree stratum the changes consist firstly in the appearance of *Callicoma serratifolia*, a type which did not occur on the basalt. Here may also be mentioned *Acacia melanoxylon* and *Lomatia longifolia*, which occurs as a small tree; these two types occurred on the basalt, but not in the *Ceratopetalum-Doryphora* association. Another feature of this stratum is the frequency of *Elaeocarpus reticulatus*, *Quintinia Sieberi*, *Acacia elata* and *Eugenia Smithii*, all of which were comparatively rare in the *Ceratopetalum-Doryphora* association on the basalt.

Tree-ferns are no longer subdominant: the *Dicksonia* stratum-society, which was such a conspicuous feature in the basalt Rain-Forest, is confined chiefly to erosion channels on the gully slopes and to the creek-beds at the base; here, moreover, *Dicksonia* is replaced to a certain degree by *Todea barbara*, a type, like *Callicoma*, confined to the sandstone. In shallow gullies, on the north-western side, where the forest is more open, *Alsophila australis* is present in the creek beds. On the slopes of the gullies, in contradistinction to the water-courses, tree-ferns are only occasional, their place being taken by *Drimys dipetala*, which is much more common than on the basalt. *Citriobatus* is now very rare and *Hymenanthera* is apparently absent, although *Prostanthera lasianthos* and *Senecio dryadens* still occur.

Perhaps the most striking differences are found in the fern stratum. In the case of the association on the basalt, two fern societies were found, namely, *Blechnum discolor* in the more illuminated patches, and a mixed society dominated by *Polystichum aculeatum*. On the sandstone, however, *Polystichum aculeatum* is absent excepting in the ecotone region, and its place is taken by societies of *Blechnum capense*; *Blechnum discolor* is still present, but it occurs scattered



Text-figure 4. Chart of a portion of the *Ceratopetalum-Doryphora* Forest on the sandstone slopes. Scale 1 inch = 8 feet.

as well as in societies: *Blechnum cartilagineum*, often co-dominant with *Gleichenia flabellata*, tends to take the place of *B. discolor* in the basalt Rain-Forest as dense societies in the more open parts; *Blechnum Patersoni* and *Polystichum* are more common; while *Todea Fraseri*, *Histiopteris incisa* and *Asplenium bulbiferum* appear for the first time.

Creepers, epiphytes, and the ground stratum are much as in the basalt Rain-Forest, but the frequent occurrence of sandstone boulders and cliffs in the gullies introduces a lithophytic element, not before observed.

The accompanying chart (Text-fig. 4) gives an idea of the structure and composition of the association as above described, and is of interest when compared with the similar chart of the basalt Rain-Forest (Part I, Text-fig. 1).

These are the outstanding peculiarities of the *Ceratopetalum-Doryphora* association on the sandstone as compared with the same association on the basalt; it must be admitted, however, that the differences are only of a minor nature, being confined to the subordinate species. The most outstanding peculiarity is probably the restriction of the tree-ferns to the neighbourhood of the water-courses, which alone tends to make a change in the physiognomy of the association.

It remains, nevertheless, to make some tentative suggestions for such differences as do occur between these two expressions of the Rain-Forest. In the first place, certain types are definitely confined to sandstone, being unable apparently to tolerate the rich and heavy basalt soil: such are *Callicoma*, *Todea* spp., *Blechnum capense* and *Histiopteris*. In the same way it appears that *Polystichum aculeatum*, *Citriobatus*, *Hymenanthera* and *Tylophora* are confined to the basalt soil, *Polystichum aculeatum* and *Blechnum capense* being parallel species. It might be suggested that competition plays a part in determining these restrictions of habitat, but the absence of even an occasional individual from the repudiated soil seems to abrogate such a possibility. Nevertheless, that other factors do come into play to some extent in these instances is shown by the occurrence of an isolated *Todea barbara* in a creek which forms the head-waters of the tributary of the Bowen, running through the *Eucalyptus Blaxlandi-E. goniocalyx* association on basalt; possibly running water in some way acts as a compensating factor here, and, moreover, on the sandstone, too, *Todea barbara* generally shows a preference for water-courses.

If in these types, however, competition is not a factor governing habitat preferences, there are a number of instances in which it does play an important part. The dominance of *Ceratopetalum* and *Doryphora* in the Rain-Forest of the basalt was so great that other trees were given little opportunity of spreading; but in the *Eucalyptus-Doryphora* ecotone, where there is a more open structure resulting from the presence of *Eucalyptus*, the possibility of ecesis of other species is enhanced, and so a greater variety exists in the tree stratum. Now a number of these trees which are given this greater chance in the *Eucalyptus-Doryphora* ecotone are conspicuous in the *Ceratopetalum-Doryphora* association on the sandstone also. Here the evidence is against their possessing any edaphic preferences apart from moisture requirements, since they occur as frequently on the basalt as on the sandstone, provided they are given the opportunity; the suggestion is therefore offered that the dominance of *Ceratopetalum* and *Doryphora* is less effective on the sandstone habitat, and the other trees are given a greater chance in competing against them. Such trees are *Quintinia*, *Acacia elata* and *A. melanoxylon*, and most probably *Elaeocarpus reticulatus* and *Eugenia Smithii*.

The presence of *Lomatia longifolia* as a tree is also explained in this manner, because, although not so far observed in the *Eucalyptus-Doryphora* ecotone, it occurs abundantly as a shrub in certain parts of the *E. Blaxlandi-E. goniocalyx* association on basalt. Likewise, the presence of *Prostanthera lasianthos*, *Alsophila australis* and *Senecio dryadens* in both the *Eucalyptus-Doryphora* ecotone and the sandstone Rain-Forest is probably due to the less effective reaction of the dominants upon the subordinate strata.

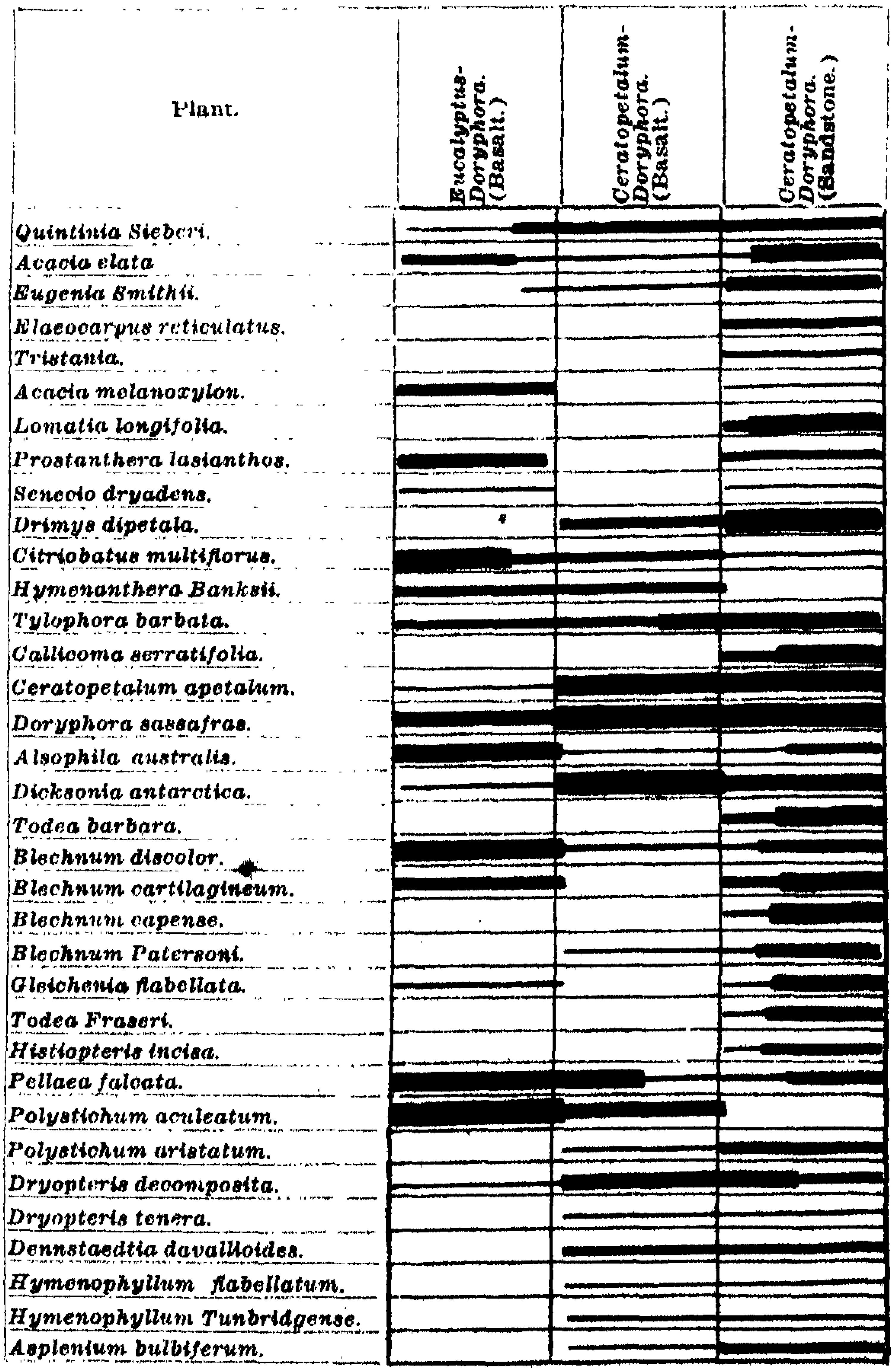
The restriction of *Dicksonia* so much to the creeks and water-courses can be attributed so far only to the possibility that the soil of a sandstone slope has a lower moisture-content than that of the basalt. This difference in moisture-content is unlikely of itself to be great enough to delimit thus largely the distribution of *Dicksonia*, more especially as occasional individuals do occur on these slopes; but it is probably enough to handicap it so much in the competition which must inevitably take place in this stratum with *Drimys*, that the latter gains a considerable ascendancy. Where the soil is damper, *Dicksonia* attains a much greater supremacy, especially when, in addition, the light is a little greater than the optimum for the intensely ombrophilous *Drimys*, as appears probable in the basalt Rain-Forest.

An interesting example of compensating factors has a certain significance in the distribution of the ferns in the Rain-Forests. On the damp basalt soil it will be remembered that a society dominated by *Polystichum aculeatum* occurs in the dense shade, while societies of *Blechnum discolor* occur where the light is stronger, and in the still more open *Eucalyptus-Doryphora* ecotone, where perhaps the soil has a lower moisture-content, *Blechnum cartilagineum* societies are found. In the sandstone Rain-Forest, although these types are often distributed in this manner, with the exception that *Polystichum* is replaced by *Blechnum capense*, in many instances the lower moisture-content of the slope appears to act to a certain extent as a compensating factor, replacing the factor of increased insolation: thus on these slopes *Blechnum discolor* may occur in habitats as dark as those of *Polystichum aculeatum*, as does *B. capense*; and dense societies of *B. cartilagineum* occur in habitats where the light intensity would have been the optimum for *B. discolor* on the basalt.

In the depth of the sandstone gullies on the south-eastern side of the plateau at the base of precipitous cliffs, far lower light intensities are found than in any habitat on the basalt, and this factor allows *Polystichum aristatum*, *Blechnum Patersoni* and *Asplenium bulbiferum*, which are extreme sciophytes, to gain greater ascendancy in the competition with the other members of the fern-stratum.

The presence of sandstone boulders and cliffs in the gullies also provides a suitable habitat for a number of more or less lithophytic types, some of which found no home on the basalt, such as *Polypodium australe*, while others, such as *Asplenium bulbiferum*, were able to gain a footing here and there on a tree-trunk. Thus in the case of *Asplenium bulbiferum*, two factors combine to add to its frequency. *Todea Fraseri* is largely confined to wet rock-faces on the sandstone, and it may be that it is the absence of such rocks rather than the nature of the basalt soil which confines it to the sandstone Rain-Forest. These rocks also provide a habitat which is availed of by *Blechnum capense*, although in this case its presence on the sandstone soil throughout the Forest shows that it possesses exclusive soil preferences.

An attempt has been made in the accompanying table (Text-fig. 5) to indicate the chief differences in the composition of the sandstone Rain-Forest in comparison with that of the basalt Forests.



Text-figure 5.—Diagram illustrating the range and relative frequency of the chief constituents of the *Ceratopetalum-Doryphora* Association throughout the basalt and the sandstone at Mount Wilson.

The most salient outcome of this analysis is that in the great majority of cases the differences in composition of the Rain-Forest on the two habitats *appear* to be due *directly* to soil preferences, but are in reality only *secondarily* so. Most of the components of the *Ceratopetalum-Doryphora* association occur both on the basalt and the sandstone. On the former habitat, however, there is an extraordinary aggregation or massing of the types, which imparts the characters of density and luxuriance to the forest. How far these qualities are due to chemical properties of the soil on the one hand, and to the differences in moisture-content and shelter on the other, is a problem which will be investigated later.

Floristic Composition.

	Basalt.	Sandstone Valleys.
Tree Stratum.		
Ceratopetalum apetalum Don.	d	d
Doryphora sassafras Endl.	d	d
Elaeocarpus reticulatus Sm.	v-r	c-o
Callicoma serratifolia Andr.	—	o-f
Hedycarya angustifolia Cunn.	o-vr	?
Quintinia Sieberi DC.	o-vr	o
Atherosperma moschatum Labill.	r	?
Acacia elata Cunn.	r	f-r
Eugenia Smithii Poir.	r	o
Acacia melanoxylon R. Br.	—	r
Tree Fern Stratum.		
Dicksonia antarctica Labill.	sd	f
Drimys dipetala F. v. M.	o	o-c
Citriobatus multiflorus Cunn.	o	vr
Hymenanthera Banksii F. v. M.	o	—
Alsophila australis, R. Br.	r	r-o
Todea barbara Moore.	—	a-o
*Lomatia longifolia** R. Br.	—	o-f
Prostanthera lasianthos Labill.	—	o
Senecio dryadens Sieb.	—	r
Fern Stratum.		
Blechnum capense Schlecht.	—	a-o
Polystichum aculeatum Schott.	c	—
Dryopteris decomposita Kuntze.	f	o-f
Athyrium umbrosum Ait.	f	r-o
Pellaea falcata Fée.	f-r	r-o
Blechnum discolor Keys.	o	f-o
Dryopteris tenera Chr.	r	r
Polystichum aristatum Presl.	r	o
Dennstaedtia davallioides† Moore.	o	o
Blechnum Patersoni Mett.	vr	r-f
Todea Fraseri Hook. & Grev.	—	f-o
Drimys dipetala F. v. M. (seedlings)	r-o	f
Gleichenia flabellata R. Br.	—	c-o
Histiopteris incisa Sm.	—	o-or
Blechnum cartilagineum Swartz.	—	o-a
Goodenia ovata Sm.	—	r
Doodia aspera R. Br.	—	r in open parts
Asplenium bulbiferum Forst.	—	o
Creepers.		
Polypodium diversifolium Willd.	f	o
Vitis hypoglauca F. v. M.	f	o-f
Tylophora barbata R. Br.	f-o	—

* This attains a height midway between that of *Drimys* and the tall trees.

† Recorded as rare in Part I.

Floristic Composition—Continued.

	Basalt.	Sandstone Valleys.
Polypodium pustulatum Forst.	o	r
Fieldia australis Cunn.	o	f
Tecoma australis R. Br.	f-o	o
Tylophora sp.?	—	o-r
Smilax australis R. Br.	vr	r in open parts
Marsdenia suaveolens R. Br.	—	vr
Epiphytes.		
Trichomanes venosum R. Br.	f-o	f
Cyclophorus serpens Chr.	o	o
Dendrobium pugioniforme Cunn.	o	o
D. teretifolium R. Br.	o	o
Tmesipteris tannensis Bernh.	r-o	o
Asplenium bulbiferum Forst.	r	r
Quintinia Sieberi DC. (seedlings)	r-o	o
Bryophytes and Fungi	c	—
Lithophytes.		
Aneura sp.	—	o in societies
Pellia sp.	—	o " "
Other Bryophytes	c	c
Hymenophyllum tunbridgense Sm.	—	o in societies
Hymenophyllum flabellatum Labill.	—	vr
Asplenium flabellifolium Cav.	r	o
Various crustaceous Lichens (not identified)	c	c
Polypodium australe Meth.	—	o
Leucobryum candidum	—	o in societies
Hymenophyton flabellatum	—	o " "
Hypnodendron tomentosum	—	f " "
Pallavicinia sp.	—	f " "
Dicranum sp.	—	o " "
Asplenium bulbiferum Forst.	—	o
Ground Stratum.		
Clematis aristata R.Br. (seedlings)	—	o
Dawsonia sp. in societies	o	o
Fungi (Agaricaceae and Polyporaceae)	f	f
Stellaria flaccida Hook.	—	r in open parts
Viola betonicifolia Sm.	—	r " " "
Hydrocotyle asiatica L. in open parts	o	o
Viola hederacea Labill.	o	r

The Eucalyptus Forests of the Slopes.

Just as the distribution, extent and luxuriance of the *Ceratopetalum-Doryphora* association of the gullies and basaltic soil vary with the aspect, so does the composition of the *Eucalyptus* Forests; and, although the classification, structure and composition of these Forests have been dealt with to some extent in Part II, it remains to discuss this distribution in the gullies, noting such variations as occur in their structure and composition from what was previously described.

The Eucalyptus goniocalyx-E. Blaxlandi Association.

From what has already been written it will be apparent that this association is one which occurs on the fringes of the basalt too exposed in aspect to be colonized by Rain-Forest, and on the edges of the sandstone adjacent to the basalt; it is thus a community requiring a degree of soil-moisture not found on the barren sandstone plateau; so that it is natural to find it in the sandstone gullies in association with the Rain-Forest.

The *Eucalyptus goniocalyx* consociation, with *E. Blaxlandi* (f-a) and *E. oreades* (l), is the most widely distributed expression of the association, occurring

frequently on the basalt as well as in the valleys in association with the Rain-Forest. On the northern and western slopes of the gullies, where the Rain-Forest does not spread out of the creek bed, the *E. piperita* consociation occupies the whole of the slope, the *E. goniocalyx-E. Blaxlandi* association being represented only fragmentarily by scattered trees between the two communities. On north-east and east slopes, on the contrary, the *E. goniocalyx* consociation forms a continuous forest from the basalt caps down to the Rain-Forest in the bottom of the valley. These slopes, although stratigraphically sandstone, are probably contaminated with basalt detritus to a certain extent, and they are crossed by numerous water-channels which join the rain-forest-clad creek-bed in the gully, down which the rich red basalt soil is clearly seen to have been transported a considerable distance. These facts, in addition to the sheltered aspect, no doubt contribute to making this a suitable habitat for the *E. goniocalyx* consociation.

On the basalt caps the *Alsophila* society forms the subordinate layers, except, as was mentioned in Part I, on the exposed westerly apex of the ridges, where the *E. Blaxlandi* consociation occurs with the *Pteridium* society; below the basalt, however, this society is confined to the drainage-channels already mentioned, where it merges into the vanguard of the Rain-Forest, which, in places, appears to be migrating up these channels, as has been previously described. In some of these troughs, however, a *Callicoma* society occurs having the following composition:

Small Trees.		Ferns.
Callicoma serratifolia Andr.	a	Typical *Blechnum* stratum-society of the *Alsophila* society (List, Part I, p. 490).
Acacia elata A. Cunn.	f	
Tree Ferns.		
Todea barbara Moore	a	
Alsophila australis R. Br.	f	
Dicksonia antarctica Labill	o	

The areas between the drainage-troughs are occupied by the *Pteridium* society characteristic of much of the *Eucalyptus goniocalyx-E. Blaxlandi* association. *Lomatia longifolia* occurs also in frequent societies, especially nearer the ends of the headlands, where the exposure is somewhat greater (see Text-figure 3).

As one approaches the apex of such headlands, of which the above is a description of the vegetation of the north-east slope, *Eucalyptus Blaxlandi* becomes more abundant in the *Eucalyptus goniocalyx* consociation, until it is co-dominant; this may be regarded as an ecotone region, for the apex of the basalt residual is occupied by a *Eucalyptus Blaxlandi* consociation, with *E. goniocalyx* (o). Although the soil is here composed of semi-weathered basalt, no tree-ferns are present, and the *Pteridium* society occurs as has been described in Part I (p. 493). To the list given there, the following additions may be made:

Shrub Stratum.		Fern Stratum.	
Daviesia ulicina Sm.	f	*Xerotes Brownii* F. v. M.	f
Acacia penninervis Sieb.	o-f	*Panax sambucifolius* Sieb.	o
Astrotricha floccosa DC.	o	*Leucopogon lanceolatus* R.Br.	r
Acacia longifolia Willd.	r	Climbers.	
		Tylophora barbata R.Br.	c

Coming to a consideration of a south or south-east slope, we find there is a great limitation in the *Eucalyptus* Forest. Such slopes, as previously explained, are clothed with the *Ceratopetalum-Doryphora* association, except for

about 50 to 100 feet at the upper limit, where the *Eucalyptus goniocalyx* consociation occurs as a narrow strip extending round the south, east and south-east slopes of the basaltic hill. This consociation gives place to the *Eucalyptus-Doryphora* ecotone and then to the Rain-Forest below, and above on the wind-swept crown, to the *Eucalyptus Blaxlandi* consociation, and then to the *E. piperita* consociation on the north-westerly slope (Text-fig. 2).

In one locality on such a southerly slope was observed a narrow shoulder down which *Eucalyptus goniocalyx* and *E. Blaxlandi* have migrated, dense Rain-Forest occurring on each side; a fire had, however, passed through this strip of *Eucalyptus Forest* some time previous to our visit, which prevented any accurate conception being formed of the original nature of the community, although many of the blackened *Eucalyptus* trunks were recovering and sending forth a great mass of adventitious shoots. This strip of *Eucalyptus* Forest is continuous with that on the basalt above belonging to the *Eucalyptus goniocalyx-E. Blaxlandi* association, and has apparently migrated down the narrow and more exposed shoulder of the slope from which the Rain-Forest has been excluded. The accompanying diagram illustrates the distribution of the communities on this slope. (Text-fig. 6).

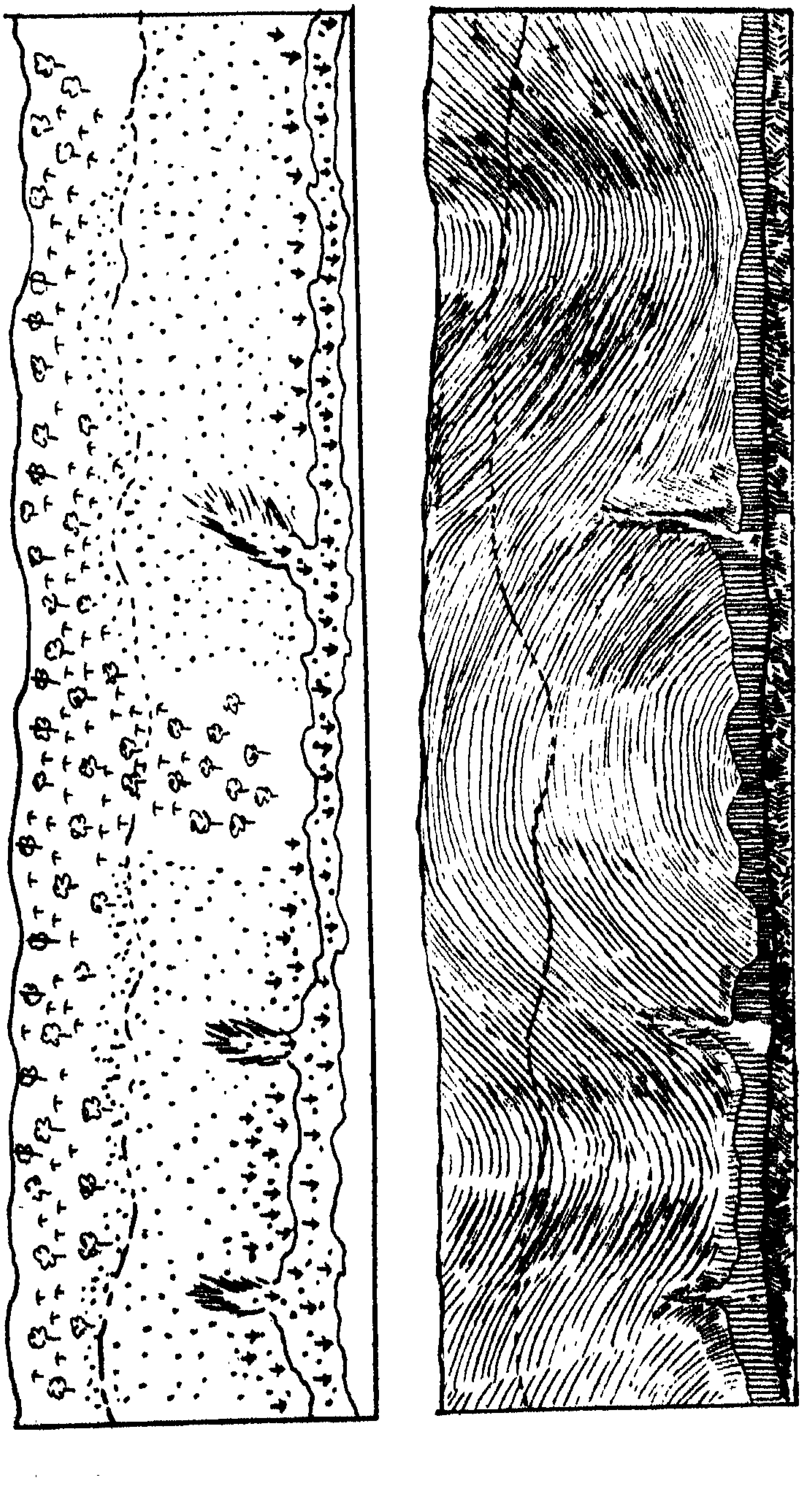
THE EUCALYPTUS OREADES CONSOCIATION.

Eucalyptus oreades has already been recorded as a subordinate of the *E. goniocalyx-E. Blaxlandi* association, but it occurs also as a consociation dominant on spurs of certain south-east slopes towards the Mount Irvine boundary of the Mount Wilson area. We have included this consociation tentatively in the *Eucalyptus goniocalyx-E. Blaxlandi* association, but at the same time its floristic composition differs considerably from that of the latter community; the interpretation of this, however, may lie in the fact that this is a more mesophilous expression of the association, the habitat conditions permitting the entrance of a number of types from the sandstone Rain-Forest which occupies the erosion-channels between the spurs. *Eucalyptus oreades* appears confined in its distribution to sheltered slopes, and in the habitat in question seems to meet such optimum conditions as to be able to gain ascendancy over such trees as *Eucalyptus Blaxlandi* and *E. goniocalyx*.

The *Eucalyptus oreades* Forest is burnt out in patches, and here *Callicoma* is seen producing adventitious shoots from a subterranean root-stock in great abundance. *Goodenia ovata* also is common in these areas.

Floristic Composition.

Tall-Tree Stratum.	
Eucalyptus oreades R.T.B.	d
E. Blaxlandi J.H.M. & R.H.C.	o-r
E. goniocalyx F.v.M.	o-r
Small-Tree Stratum.	
Callicoma serratifolia Andr.	a
Acacia elata A. Cunn.	f-a
Prostanthera lasianthos Labill.	f
Doryphora sassafras Endl.	o
Tall-Shrub Stratum.	
Callicoma serratifolia Andr.	a
Acacia elata A. Cunn.	f-a
Dicksonia antarctica Labill.	f
Persoonia mollis R.Br.	f
Zieria Smithii Andr.	o
Tall-Shrub Stratum (continued).	
Acacia longifolia Wendl.	o
Todea barbara Moore	o
Cassinia longifolia R.Br.	o
Fern Stratum.	
Gleichenia flabellata R.Br.	a
Blechnum discolor Keys.	f
Blechnum capense Schlecht.	o-a
Goodenia heterophylla Sm.	o-f
Blechnum cartilagineum Swartz.	o
Goodenia ovata Sm.	o
Pteridium aquilinum Kuhn.	f
Astrotricha floccosa DC.	o
Climber.	
Billardiera longiflora Labill.	o



Eucalyptus goniocalyx.
Eucalyptus Blaxlandi.
Ceratopetalum-Doryphora association.
Alsophila australis stratum society.
Dicksonia antarctica stratum society.

Text-figure 6.—Diagrammatic sketch of a slope with southern exposure, showing the distribution of the chief plant communities in relation to the topography and the geological formation. The broken line indicates the lower limit of the basalt covering upon the sandstone.

EUCALYPTUS PIPERITA-E. HAEMASTOMA VAR. MICRANTHA ASSOCIATION.

EUCALYPTUS PIPERITA CONSOCIATION.

This, as has already been seen, is the most characteristic community of the sandstone plateau. Where the sandstone adjoins the basalt on a level tract, it approaches close to the *Alsophila* society; but, as has been described, when the basalt thins out on a steep slope and extensive leaching is possible, it is usual to find either Rain-Forest, as was seen on the southerly slopes, or the *Eucalyptus goniocalyx-E. Blaxlandi* association, as was seen on the north-easterly slopes. Quite a different state of affairs, however, is found on northern and western valley-slopes, which are occupied by the xerophilous *Eucalyptus piperita* consociation, even when the summit of the slope is capped with basalt.

The occurrence of the *Eucalyptus piperita* consociation on these slopes is of peculiar interest, because this is the only habitat in which the community extends actually on to the basalt, where it abuts the *E. Blaxlandi* consociation on the summit. It seems curious that *E. piperita* should occur on the basalt here, when even a slight detritus appeared sufficient to supplant it on the other side of the hill; and this only adds to the conclusion that distribution at Mount Wilson seems very largely a question of moisture relationships and aspect rather than of soil constitution: the *Eucalyptus goniocalyx* consociation requires a comparatively damp soil and sheltered environment, and when it finds this, competition keeps out *E. piperita*, while on the western slope the exposure and dryness of the soil are too great for this consociation to compete successfully with *E. piperita* (see Text-fig. 2).

Beneath the *Eucalyptus piperita* trees on the basalt occurs a *Lomatia* stratum-society, of which the composition, however, closely approximates to that of the *Pteridium* society of the *E. Blaxlandi* consociation of the summit. The floristic composition of the society is as follows:

Tall-Shrub Stratum.		Ground Stratum.	
Acacia longifolia Willd.	r	*Poranthera microphylla* Brongn.	c
Daviesia ulicina Sm.	r	*Xerotes Brownii* F. v. M.	c
Low-Shrub Stratum.		*Tylophora barbata* R.Br.	c—near *E. Blaxlandi* consociation.
Lomatia silaifolia R.Br.	a		
Pteridium aquilinum Kuhn.	c		
Trachymene linearis Spreng.	f		
Dianella sp.	f		
Ampera spartioides Brongn.	o	Grasses	f

Occasional societies of *Pultenaea flexilis* occur here also.

Nearer the sandstone edge the following additional components appear:

Telopea speciosissima R.Br.	c	*Persoonia salicina* Pers.	o
Ampera spartioides Brongn.	f		

Passing on to the sandstone we have the more typical shrub society of the consociation, as has been described in Part II; we append the following list made of the shrubs on one of these slopes, however, since there are some interesting points of divergence from the normal state as previously recorded:

Low-Tree Stratum.		Low-Tree Stratum (contd.).	
Callicoma serratifolia Andr. (Saplings) (half-way down sandstone slope)	f	*Persoonia salicina* Pers.	o
		Leptospermum flavescens Sm. (more than half-way down sandstone slope)	o
Banksia serrata L.f. (half-way down sandstone slope)	f	Tall-Shrub Stratum.	
		Persoonia salicina Pers.	f

Tall-Shrub Stratum (contd.).		Low-Shrub Stratum (contd.).	
Telopea speciosissima R.Br.	f	*Ampera spartioides* Brongn.	o
Banksia collina R.Br.	o	*Candollea linearis* F. v. M.	o
Choretrum Candollei F. v. M.	o	*Caustis flexuosa* R.Br.	o
Acacia discolor Willd.	o	*Dampiera stricta* R.Br.	o
Pultenaea scabra R.Br.	o	*Leucopogon lanceolatus* R.Br.	r
Acacia longifolia Wendl.	o	*Goodenia heterophylla* Sm.	r
Haemodorum planifolium R.Br.	r	*Ionidium filiforme* F. v. M.	r
Petrophila pulchella R.Br.	vr	*Patersonia sericea* R.Br.	r
Low-Shrub Stratum.		*Tetratheca thymifolia* Sm.	r
Dianella revoluta R.Br.	f	*Lindsaya linearis* Sw.	r
Lomatia silaifolia R.Br.	f	*Comesperma ericinum* DC.	vr
Trachymene linearis Spreng.	o	Parasites.	
Xerotes flexifolia R.Br.	o	*Loranthus pendulus* Sieb.	r

It is curious to note the entire absence of *Banksia spinulosa*, *B. marginata* and *Hakea dactyloides*, and the rareness of *Isopogon* and *Petrophila*, all of which are usually conspicuous in this consociation.

At the base of these westerly or south-westerly slopes dense societies of saplings and regenerating shoots of *Callicoma* appear in drainage-channels, often extending into the strip of Rain-Forest in the creek-bed.

In one instance a *Baeckea linearis* society was observed, having the following composition:

Baeckea linearis Rudge.	d	*Goodenia heterophylla* Sm.	o
Dampiera stricta R.Br.	f	*Acacia longifolia* Wendl.	r
Selaginella uliginosa Spreng.	f	*Ionidium filiforme* F. v. M.	r
Lindsaya linearis Sw.	f	*Acacia discolor* Willd. (seedlings)	r
Trachymene linearis Spreng.	o		
Candollea linearis F.v.M.	o		

EUCALYPTUS HAEMASTOMA VAR. MICRANTHA CONSOCIATION.

On one part of the south-westerly slope just described (that surmounted by block 53 in Map), there is a small spur projecting in a due westerly direction, which is very exposed, and is occupied by the *Eucalyptus haemastoma* var. *micrantha* consociation. The floristic composition of the shrub strata here is interesting, since they contain a number of the types whose absence was noteworthy in the *Eucalyptus piperita* consociation on this slope.

Tall-Shrub Stratum.		Low-Shrub Stratum.	
Dillwynia ericifolia Sm.	f	*Tetratheca ericifolia* Sm.	o
Persoonia salicina Pers.	f	*Candollea linearis* F. v. M.	o
Isopogon anemonifolius R.Br.	f	*Caustis flexuosa* R.Br.	o
Leptospermum stellatum Cav. var. *grandiflorum* Benth.	o	*Xanthosia pilosa* Rudge.	o
Hakea dactyloides Cav.	o	*Symphyonema montana* R.Br.	o
Leptospermum stellatum Cav.	o	*Epacris* sp.	o
Banksia serrata L.f.	o	*Calochilus campestris* R.Br.	o
Choretrum Candollei F. v. M.	o	*Dracophyllum secundum* R.Br.	lf on rocks
Hakea gibbosa Cav.	o	*Boronia pinnata* Sm.	r
Banksia marginata Cav.	r	*Actinotus Helianthi* Labill.	r
Eucalyptus stricta Sieb.	vr	*Cryptostylis longifolia* R.Br.	vr

Such exposed areas as these usually have a shallow soil, owing to the erosive action of wind. In one part, where the rock comes very close to the

surface, were found the following types, most of which, it will be remembered, were found on an exposed headland described in Part II:

Banksia ericifolia L.f.	o	*Hakea gibbosa* Cav.	o
Conospermum ericifolium Sm.	o	*Petrophila pulchella* R.Br.	o
Hakea pugioniforme Cav.	o	*Isopogon anemonifolius* R.Br.	o
Goodenia bellidifolia Sm.	o		

SUCCESSION.

We have come to recognize three climax communities at Mount Wilson, namely, the *Ceratopetalum-Doryphora* association, the *Eucalyptus goniocalyx-E. Blaxlandi* association, and the *Eucalyptus piperita-E. haemastoma* var. *micrantha* association. The *Eucalyptus-Doryphora* ecotone, however, represents an invasion of the second of these associations into the first: it is, in fact, the second stage of a sere, commencing with the *Ceratopetalum-Doryphora* association, and leading to the *Eucalyptus goniocalyx-E. Blaxlandi* association. Where the ecotone occurs in a zone between these two associations we see the invasion just commencing: where it occupies the whole of a basalt slope we see the second stage of the sere in its fullest expression; and the community has assumed the rank of an associes, or association, as it was termed in Part I. It is highly probable that such a slope was originally clad with the *Ceratopetalum-Doryphora* Forest; and there is little doubt also that, as the basalt is slowly weathered away, the Rain-Forest types will dwindle; the ecesis of *Eucalyptus* will concomitantly grow more rapid as the increased insolation of the forest floor permits the readier establishment of seedlings; and finally the *Eucalyptus goniocalyx-E. Blaxlandi* association will be developed as the third stage of the sere. When the basalt has been entirely eroded from the hills there is little doubt but that this association, too, will pass away, and the *Eucalyptus piperita-E. haemastoma* var. *micrantha* association, which is the climatic climax, will take possession as a fourth and culminating stage of the sere.

Such changes as these, however, will unquestionably be very slow; and at the present, apart from occasional oscillation in the ecotone zone, no apparent succession is taking place in the Rain-Forest, since the light conditions there absolutely prevent the ecesis of *Eucalyptus* so long as the Rain-Forest maintains its complete expression.

Moreover, the succession which we have described as occurring in erosion-channels on the north-east slopes shows that the Rain-Forest in its own environment is as aggressive as the *Eucalyptus* Forest, for precisely the reverse stages of succession are taking place from what have been outlined above: the Rain-Forest is invading and supplanting the *Eucalyptus goniocalyx* consociation as the erosion-channels become deeper and the habitat more favourable.

SEMI-NATURAL VEGETATION.

The extremely fertile soil of this district has naturally led to a certain amount of settlement, with its consequent destruction or modification of the pre-existing natural forests over considerable areas. Moreover, the opening up of the district by the formation of a road through it to Mount Irvine, and the cultivating and grazing of certain areas, have undoubtedly produced a marked change. The part which has suffered most is the *Eucalyptus goniocalyx-E. Blaxlandi* association: many of the large trees have been cut out of certain areas, although the tree-ferns have been usually left, along with occasional individuals of *Acacia*

melanoxylon. The tree-ferns, however, are not quite happy under the new conditions of exposure resulting from the destruction of the trees, while the fern-stratum has disappeared, no doubt as a result of grazing and exposure. Various European fodder-grasses have been sown in some parts, and an abundance of weeds has appeared in consequence; many of these exotic grasses and weeds are found also along the margin of the road which traverses the district.

Semi-natural vegetation has been further rapidly produced in private ground by the introduction of a large variety of exotic trees, both Gymnosperms and deciduous Angiosperms, the most important being:

Pinus insignis.	*Larix Europaea.*
Sequoia gigantea.	*Juniperus communis.*
Cryptomeria japonica.	*Cupressus* sp.
Ulmus montana.	*Juglans regia.*
Fagus sylvatica.	*Acer pseudoplatanus.*
Castanea sativa.	*Ilex aquifolium.*
Aesculus hippocastanum.	*Taxus baccata.*
Tilia Europaea.	*Quercus robur.*
Crataegus oxyacantha.	*Fraxinus excelsa.*

Thus in consequence of these changes in the *Eucalyptus goniocalyx-E. Blaxlandi* association of the basalt, we find remarkably English-like fields and avenues, abutting upon the natural association or upon the *Ceratopetalum-Doryphora* Forest.

In another part of the district the *Ceratopetalum-Doryphora* Forest was cleared from several acres on the top of a basaltic hill about ten years ago; since then the area has been somewhat neglected, being used only for occasional grazing. At the present time it shows an interesting secondary succession. *Ceratopetalum* has shown no signs of regeneration, but *Doryphora* has formed extensive clumps arising from old root-stocks, while numbers of seedlings are developing over the area, having migrated from the Rain-Forest around the clearing. The only other Rain-Forest types observed were a few shrubs of *Citriobatus* and *Hymenanthera*. The most important development, however, was the almost complete covering of grasses and weeds, together with clumps of *Sonchus* sp. and societies of *Pteridium*.

It is interesting to note that, with the exceptions of *Citriobatus* and *Hymenanthera*, the Rain-Forest components appear unable to re-establish themselves here without the normal protective canopy of the forest trees. It is possible that this may eventually be formed by *Doryphora*, after which other types may follow. It is at all events interesting to observe that so far *Eucalyptus* has not succeeded in establishing itself in this area.

Note on the Loranthaceae.

The Loranthaceae are represented by three parasites in the valley flora, namely, *Viscum articulatum* on *Doryphora sassafras*, and *Loranthus celastroides* and *L. pendulus* on the species of *Eucalyptus*. The latter were common in some of the valleys, especially those with a sheltered position; they were seen upon *E. viminalis*, *E. Blaxlandi* and *E. goniocalyx* on the basalt, and on *E. oreades*, *E. piperita* and *E. Sieberiana* on the sandstone slopes.

Conclusion.

With this paper the bulk of the primary survey of the Mount Wilson area is completed, at all events so far as the recognition of the main plant com-

munities is concerned, although we cannot claim to have characterized them all by complete lists of their subordinates. We have aimed in addition, however, at forming some conceptions of the basic factors underlying the distribution of the communities studied, so far as is possible to do so by observational methods; these we hope to supplement in a fourth part by the record of some detailed measurements, by some studies of environic response, and by a more detailed study of succession.

Summary.

1. The study of the vegetation of Mount Wilson is continued by an inquiry into the distribution of the plant communities in the valleys and on the valley slopes.

2. On the sheltered south and south-east slopes the *Ceratopetalum-Doryphora* association continues down from the basalt caps into the bottom of the sandstone valleys. In the more exposed sandstone valleys the association is confined to the creek-bed at the bottom. Migration of the Rain-Forest up erosion channels on the slopes of such valleys is recorded. A comparison of the Rain-Forest on the sandstone and on the basalt follows, with suggested interpretations of the outstanding differences.

3. The *Eucalyptus goniocalyx-E. Blaxlandi* association is represented fragmentarily along the edge of the Rain-Forest in the bottom of the more exposed gullies. It is also extensively developed on the sandstone below the basalt on north-east and east slopes.

4. A *Eucalyptus oreades* consociation occurs on spurs of certain south-east slopes towards Mount Irvine; this seems to be a more mesophilous expression of the *Eucalyptus goniocalyx-E. Blaxlandi* association.

5. Northern and western valley slopes are occupied by the *Eucalyptus piperita* consociation which extends actually on to the edge of the basalt at the top of the slope. The *E. haemastoma* var. *micrantha* consociation occurs on a small spur projecting in a westerly direction on a south-westerly slope.

6. A discussion on succession follows, together with some observations on semi-natural vegetation.

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EXPLANATION OF PLATES VIII-X.

Plate viii.

1.—Photograph showing the general topography of the Mt. Wilson area. The deep gullies are occupied by the *Ceratopetalum-Doryphora* Rain-Forest and most of the slopes by *Eucalyptus* Forests.

2.—View of the Wollongambe Gorge in the Mt. Wilson area, showing chiefly *Eucalyptus piperita* forest on the slopes. The bottom of the gorge is occupied by a narrow strip of *Ceratopetalum-Doryphora* Forest.

Plate ix.

3.—*Eucalyptus goniocalyx-E. Blaxlandi* Association showing the *Alsophila* stratum society. The trees have frequently branches of *Loranthus celastroides* or *L. pendulus* hanging from their branches.

4.—The *Ceratopetalum-Doryphora* Association in a sandstone gully. The ferns on the left are *Dicksonia* and *Todea*, while the tall fern on the right is *Alsophila australis*. The trees are *Doryphora sassafras*, with *Cyclophorus serpens* on their trunks.

Plate x.

5.—Interior of the *Ceratopetalum-Doryphora* forest on a southern sandstone slope. Note the absence of tree ferns and the abundance of lianes.

6.—*Eucalyptus oreades* consociation showing a society of slender saplings which are the result of regeneration after denudation by fire. *Acacia elata* is seen on the left and *Doryphora* on the right.

7.—Portion of *Eucalyptus goniocalyx* consociation given over to grazing, showing the replacement of the fern-stratum by grasses. *Alsophila australis* is the tree-fern in the foreground.

PRELIMINARY NOTE ON BRANCH FALL IN THE CONIFERALES.

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(Plates xi-xiii; five Text-figures.)

[Read 28th April, 1926.]

Introduction.

It is a characteristic feature of the Coniferales that twigs and branches are regularly shed, just as individual leaves are pruned off in most other vascular plants.

No detailed investigation has so far been made into this phenomenon. The morphology of the leaf fall has been discussed by many investigators. Lee (1911), the most recent of these, made an exhaustive inquiry into the mechanism of leaf fall. Lindsey (1915) has described the possible branch-shedding habit of the fossil genus *Bothrodendron*. Watson (1914) and Renier (1910) have described the Ulodendroid fossils as probable branch scars, inferring that branch fall occurred in the Lycopodiales in the Carboniferous. No inquiry has been made into the mechanism or significance of branch fall in the Conifers.

In this preliminary paper it is proposed to outline briefly the main features of the subject. Subsequent papers will contain more detailed investigations. In Section i a brief account of branch fall in the different orders of Conifers is given. Its evolution is traced and correlated with the phylogeny of the orders. Section ii contains a detailed account of the morphology of the branch fall in *Taxodium distichum*. Section iii gives a brief description of the occurrence of branch fall in fossil plants. Section iv contains the outlines of certain broad conclusions arrived at from this study.

Section i.

In most Conifers the branches are dimorphic. There are long shoots of indefinite growth and dwarf or foliar shoots of more or less definite growth. The long shoots usually bear the foliar shoots laterally. In some forms the foliage leaves are restricted to the dwarf shoots, and scale leaves only are found on the long shoots. Generally foliage leaves occur on both kinds of shoots.

In *Pinus* there are two distinct kinds of shoots, and in the adult form no foliage leaves are borne on the long shoots. The individual leaves are not shed, but the whole dwarf shoot is pruned off. Plate xi, fig. 1 illustrates this point. This shedding of the foliar branch instead of the individual leaves is a type of the phenomenon, which has been referred to as branch fall. The term cladopsis has been applied by Watson and seems very suitable.

Prepinus, a fossil from the Cretaceous, which has been described by Jeffrey (1917) as the probable ancestor of *Pinus*, bore leaves on dwarf shoots and these shoots were shed in exactly the same manner as in *Pinus*. Other fossil Conifers

found on lower horizons, if impressions, are always found as twigs. This fact is very suggestive and indicates that the habit of shedding the foliar branch was a very ancient one in the Conifers.

Other members of the Abietineae, *Larix* and *Cedrus*, generally held to be more advanced than *Pinus* on account of the more highly organized vascular structures they possess and their more recent geological history, show dimorphism in their branches. This dimorphism is not so well marked or distinct as in *Pinus*. In these types foliage leaves are borne on the long shoots as well as on the dwarf shoots. The dwarf shoot also often grows forward and becomes a long shoot. The leaves, as well as the foliar shoots, fall in both these genera.

When the short shoot in *Cedrus* does not grow forward into a long shoot it is shed after a few years. In *Larix* the fall is annual. Plate xi, fig. 2 illustrates the foliar branches of *Cedrus*.

In the seedling of *Pinus*, ordinary foliage leaves are found on the long shoots as well as on the dwarf ones, thus approaching the condition in *Cedrus*. It would, therefore, be inferred that the adult condition of *Pinus* has been derived from the *Cedrus* type. This does not seem to be the case, however, considering that: (1) The *Pinus* condition is more ancient geologically; (2) *Pinus* has been shown by Jeffrey (1917) to be more primitive in vascular anatomy than the remaining members of the Abietineae and other evidence points to the same conclusion; (3) because certain evidence in the Taxodineae, which shall be described later, indicates the primitiveness of the *Pinus* condition.

In *Abies*, *Picea*, *Ketelecria*, and *Pseudolarix* the distinction between dwarf shoots and long shoots is not so marked. The dwarf shoots can grow forward and become long shoots as in *Cedrus* and *Larix*. The leaves are shed as in the two former types also, but a considerable amount of fall takes place among the dwarf shoots.

In the Taxodineae, *Sciadopitys* approximates to the condition of *Pinus*, except that the dwarf shoot is apparently replaced by a peculiar double leaf; the long shoot bears scale leaves only, as in *Pinus*.

Taxodium, *Sequoia* and *Glyptostrobus* exhibit well marked dwarf or foliar shoots. In *Taxodium distichum*, for example, small leaves are borne laterally in one plane along the dwarf shoots. Leaves are also found on the long shoots, but these are scale-like and generally much smaller than those on the foliar branches.

In *Glyptostrobus* also, the same well defined foliar shoot exists, and the long shoots bear scale leaves only. *Sequoia sempervirens*, however, has foliage leaves on both dwarf branches and long branches. In this type also the dwarf shoots readily grow forward to form long shoots; a feature which is not usual in *Taxodium* or *Glyptostrobus*.

In both *Taxodium* and *Glyptostrobus* the foliar branches are shed annually and the individual leaves practically do not fall at all. In *Sequoia* the fall is more or less continuous, as in other types, and numbers of individual leaves are shed also.

Plate xi, fig. 3 illustrates the foliar branches of *Taxodium distichum*, and fig. 4 *Sequoia sempervirens*.

In *Cryptomeria Japonicum* and in *Arthrotaxis*, the condition of the higher Abietineae exists. There are foliar and long shoots, but these are not well differentiated. Leaf fall takes place in both of these genera, but there is a considerable fall of the foliar twigs also.

In this group, the Taxodineae, the long shoots branch more than in the Abietineae and the leaves are smaller in consequence, and, except for *Sciadopitys*, have not the needle-shape that characterizes the Abietineae. The geological history, studies of the vascular anatomy (Jeffrey, 1917), and the morphology of the reproductive structures and gametophytes indicate an origin from an Abietineous stock. *Sciadopitys* occupies a position linking up these two groups. Further, the structure of the leaf of the seedling in *Taxodium* and in other genera indicates derivation from an ancestry with needle-like leaves. The foliage in the seedling, and of shoots produced from wounds, is different from that in the adult in that the leaves are longer and more needle-like.

Admitting then the Abietinean ancestry of the Taxodineae, it will be evident that the habit of foliar shoots is a primitive feature. It is very suggestive to find that in *Taxodium* and *Glyptostrobus* the foliage leaves are almost restricted to the dwarf shoots, and to find the close approximation of *Sciadopitys* to *Pinus*. It seems to point to the fact that the condition of *Pinus*, as stated before, is the primitive condition. It is in the more advanced types that the sharp differentiation of the foliar shoot is lost. It is very improbable that the habit of foliar shoots has arisen separately in the two groups and is a case of homoplasy.

In the Cupressineae the short shoot cannot be distinguished in most cases. There are two types of branching occurring in this group. Firstly, that represented in *Cupressus*, in which the ultimate branching is generally in one plane and secondly, that represented by *Juniperus*, in which it is not in one plane.

Chamaecyparis, *Thuja*, *Thujopsis*, and *Libocedrus* follow the type of *Cupressus*, while *Callitris* and *Actinostrobus* are of the *Juniperus* type. Plate xii, fig. 5 represents a small branch of *Chamaecyparis*, and it shows the extreme ramification of the shoot and the extreme reduction of the individual leaves in consequence, which is characteristic, without exception, for all the Cupressineae. Here, however, though dwarf shoots cannot be recognized on this account, branch fall is still evident. In Plate xi, fig. 5, the lower part of the main branch shows how the lateral shoots have been shed; also, the two lowest laterals remaining show that their laterals are shed. After attaining a certain age branches of all degrees are shed.

The Cupressineae are generally held to have been derived from an Abietinean or Taxodinean stock (Jeffrey, 1917). Certainly this group is the most recent of the three. The seedlings of many genera indicate a derivation from an ancestry with spreading needle-like leaves, for in the seedlings the juvenile leaves are spreading and needle-like.

In *Thuja* it has been shown that such foliage is produced on traumatic shoots. It would seem then that the Cupressineae have been derived from an early Taxodinean stock and that extreme ramification has resulted in leaf reduction and has obliterated the distinction between foliar and long shoots. This view is in strict harmony with the accepted phylogenetic facts of tribes concerned. Notwithstanding the loss of the distinction between long and dwarf shoot, the characteristic feature of branch fall remains.

The Araucariineae are quite different. In nearly all forms there is well marked dimorphism in the branches. Foliar twigs and long shoots are very distinct. In *Araucaria Bidwillii* the main trunk of the tree bears large, generally sparingly branched laterals on which are borne short foliar twigs. These are about 7 inches long. Plate xii, figs. 6 and 7 are photographs showing the dwarf shoots and scars of these shoots on the large lateral branches. These show how the foliar shoots are shed while the leaves are persistent. Foliage leaves are

borne on the long shoots as well as on the dwarf ones so the distinction between the two kinds of shoot is not quite as definite as in the case of *Pinus*.

The degree of dimorphism is closer to that exhibited in the more primitive Taxodineae as e.g. *Taxodium* or *Sequoia*.

In *Araucaria excelsa*, and *A. Cunninghamii* and other species examined, the same habit is adhered to. Sometimes another series of branches may be inserted between the laterals from the main trunk and the foliar branches. This is the case in many species of *Agathis*. Where the leaves are large and are not crowded, the distinction of the foliar shoot may be overlooked in these types with the extra series of branches inserted. In all other respects *Agathis* agrees with *Araucaria*. The foliar branches are pruned off continuously. In addition to the shedding of the foliar twigs the oldest laterals from the main trunk are naturally cut off.

It is now generally accepted that the Araucarians are an ancient group and probably arose from an Abietinean-Araucariinean stock. Jeffrey's investigations into the anatomy and geological history of the Araucariineae seem to prove this fact. That there is a well marked distinction of the foliar shoot in the Araucariineae and that it is pruned off as in the more primitive members seems to indicate that this feature had a common origin in the two groups and is not a case of homoplasy—indicating again the primitiveness of the character.

In the Podocarpineae, illustrated by species of *Podocarpus*, notably *P. vitiensis*, the same condition of branching occurs as is found in the Araucariineae, except that the long shoots branch more freely. There is a well marked differentiation of foliar shoots. In other species of *Podocarpus* this distinction becomes lost as the higher Abietineae lose the distinction apparent in *Pinus*. In *Phaerosphaera*, *Dacrydium* and *Microcachrys* further stages are found. Ramification is greater and, as a consequence, the leaves are smaller and the condition found in the Cupressineae is obtained. The dimorphism of the branches becomes less and less evident as the ramification becomes more marked.

In this group dimorphism is almost as striking as in the more primitive Abietineae in some forms, and there are all gradations till the distinction of foliar shoot is as completely lost as in the Cupressineae. In *Phyllocladus* the dwarf shoot becomes the phylloclade and functions as a leaf. The current opinion that the Podocarpineae are probably an offshoot of the Southern Mesozoic Araucariineae accords well with these facts (Coulter and Chamberlain, 1917). That the Podocarpineae must have arisen from a group possessing dimorphic branches is evident. Other things being equal the Araucariineae seem to be the nearest allied group as stated above.

The Taxineae have not been examined more than superficially. There does not seem to be any dimorphism at all and ordinary leaf fall takes place. It only illustrates Scott's statement: "If any of the Conifers had a separate origin it is the Taxineae".

However, in conclusion, although the views expressed may be subject to considerable modification, it cannot be denied that a very good correlation exists between the habit and foliar characteristics of the subtribes and their phylogeny.

The subject of branch fall, it will be seen, is intimately connected with the dimorphic habit of the Conifers. Enough has been written to emphasize the fact that the dimorphism of branches and the habit of branch fall are features of definite phylogenetic significance. Conclusions drawn from the above considerations will be referred to later in Section iv of this paper.

Section ii.

In *Taxodium distichum* a longitudinal section of the base of a foliar branch just previous to fall shows the features illustrated in Text-fig. 1. Extending across the base of the branch is a band of cork cells about 4 cells wide, while further up the branch a layer of about 7-12 cells, with a high protoplasmic content and large nuclei, is seen. The ultimate separation of the branch takes place along this latter layer; the tissue lying between this layer and the cork cells becomes lignified and forms a protective layer after fall has occurred, while the phellogen produces more cork cells until a thick periderm is produced.

Before preparation for fall begins, the cells of the cortex of the branch are continued without change into the main shoot. The separation layer can be distinguished first in the changes that precede fall. A fairly wide band of cells at the base of the branch becomes active and the cells undergo division. This activity commences at the periphery of the branches and extends towards the vascular bundle. Shortly after the separation layer can be distinguished as a band of highly protoplasmic and active cells, a layer of cells situated further down the branch, as seen in Text-fig. 1, becomes active and forms a phellogen, cutting off thin-walled cells which become suberized.

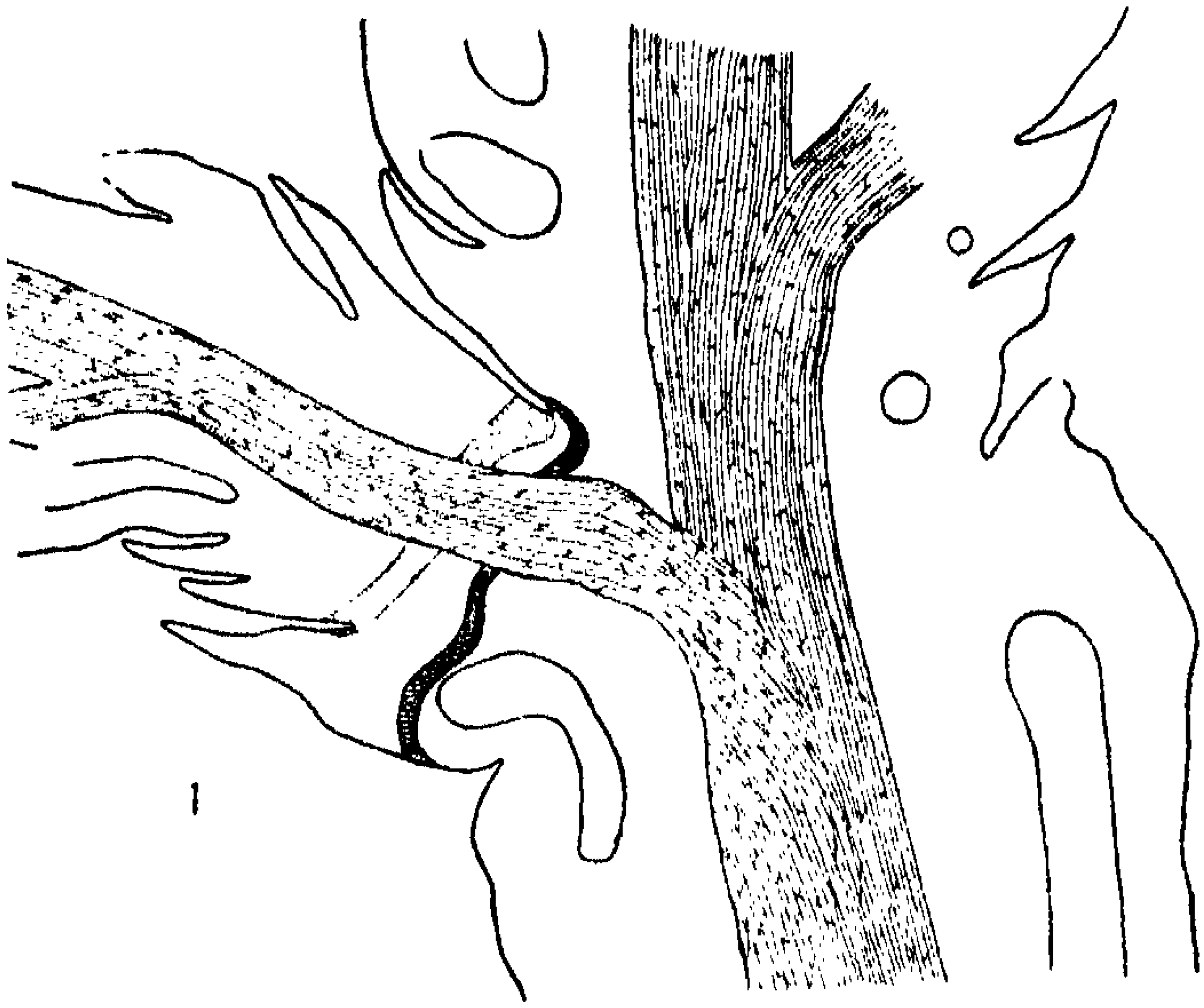
Text-fig. 2 represents a portion of Text-fig. 1 showing these three regions in detail, the separation layer, cork layer and protective layer, though the latter has not been lignified at this stage. The phellogen which gives rise to the cork cells cuts off only a few cells towards the main shoot, but produces a layer of thin-walled cells on the branch side. Sudan III, potash, iodine and H_2SO_4 gave reactions for suberin on these walls.

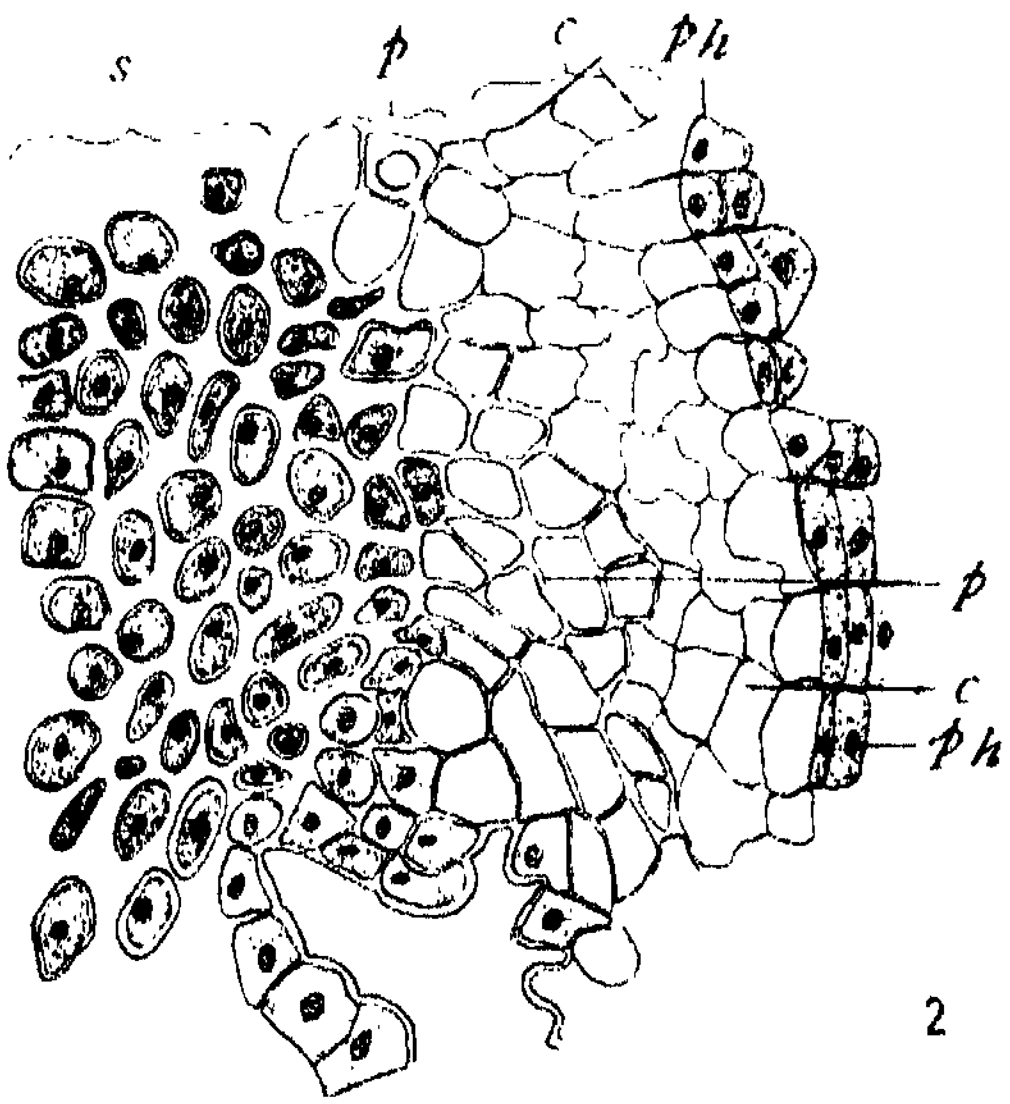
Between the cork and the separation layer in the figure, a layer about five cells across is present. The cells of this layer are practically destitute of protoplasm and the walls are becoming lignified.

At first the separation layer consists of cells with large nuclei, high protoplasmic and starch content. As fall approaches the cells seem to separate from one another as shown in Text-fig. 2. The middle lamella swells and gelatinizes and finally dissolves, leaving the cells free. This dissolution of the middle lamella may be brought about in a manner illustrated in a quotation from Hass and Hill (1918): "On boiling pectose with dilute acids or caustic alkalies a number of different substances are produced such as pectin, parapectin, metapectin and pectic acid, which is combined with bases such as calcium and forms the middle lamella of cell walls—parapectic and parapectosic acid some of which are soluble in water while others such as pectin swell up in water and gelatinize. The final product of these changes, namely metapectic acid, is readily soluble in water". Tests show pectic substances are present in the earlier stages, and it seems likely that some of the above changes take place, finally resulting in the dissolution of the wall.

The actual separation generally takes place along the inner side of the separation region, so most of this layer falls with the branch. Text-fig. 5 represents a transverse section across a fresh scar. The cork band is cross-hatched and the cells of the separation layer are stencilled, while the white zone between represents the protective layer. At this stage the protective layer consists of thick-walled cells; tests with phloroglucin and HCl and Safranin stain, show that the walls are strongly lignified. This lignified protective layer is widest towards the centre of the branch and around the vascular bundle, thinning out towards the sides. Sometimes there are patches of lignified cells in the stem side of the phellogen

such as are seen in Text-fig. 3, but these have no connection with branch fall and similar lignified patches are formed all around the cortex.



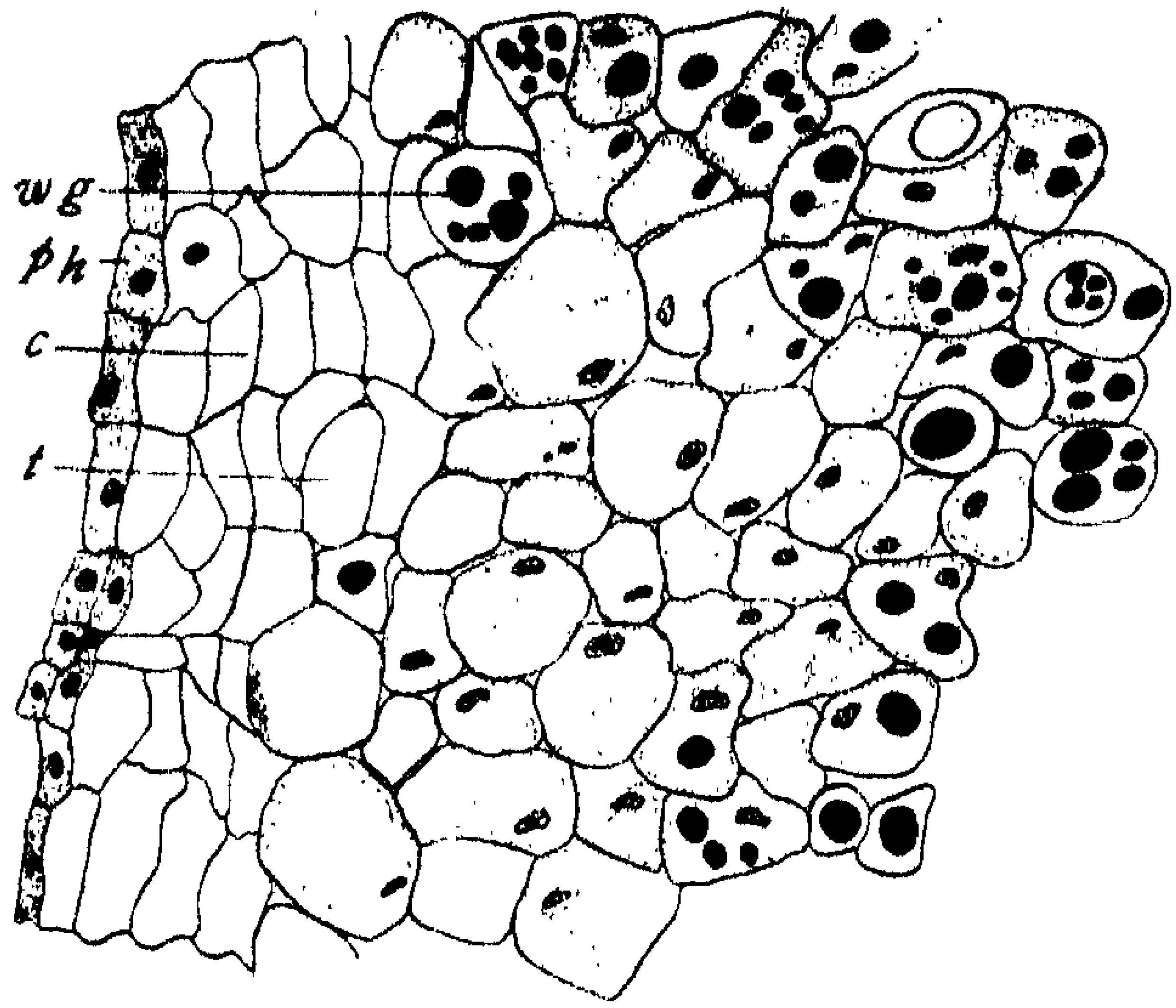


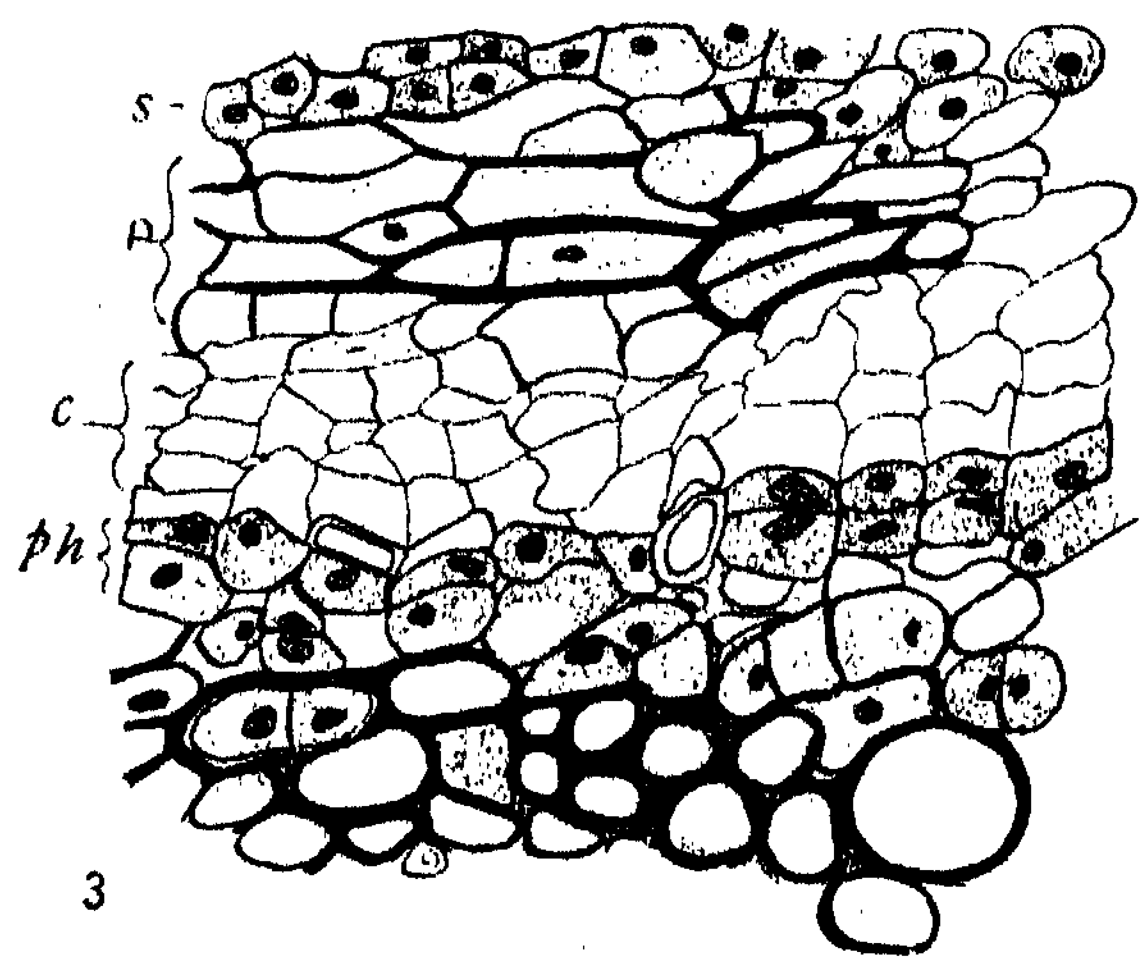
Taxodium distichum.

Text-fig. 1.—L.S. through base of foliar shoot at time of fall, showing the outlines of the separation layer, protective layer, cork layer and phellogen. Separation layer indicated by stencilling and cork by hatching. × 27.

Text-fig. 2.—Small portion of same section (× 150) showing the separation, protective, and cork layers and phellogen in detail. *s*, separation layer; *p*, protective layer; *c*, cork layer; *ph*, phellogen.

The part taken by the vascular bundle in the separation process is not too clear. As far as could be determined the living cells of the phloem and wood undergo the same changes as other cells of the separation layer in that zone.





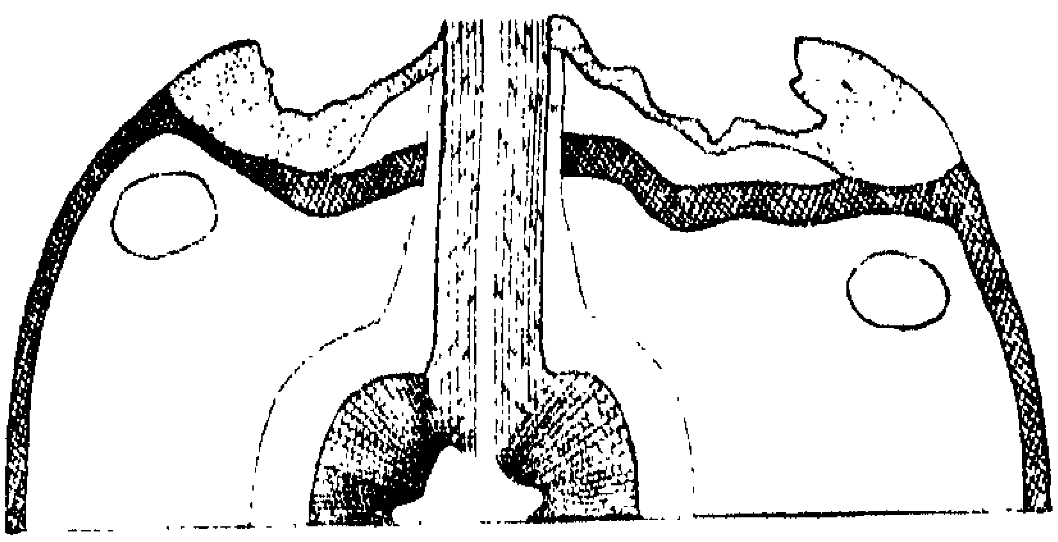
3

Taxodium distichum.

Text-fig. 3.—T.S. of same region as in Text-fig. 1 showing phellogen and cork in detail. × 150.

Text-fig. 4.—Small portion of Text-fig. 5 showing the production of wound gum in the protective and separation layers. × 150. *s*, separation layer; *p*, protective layer; *c*, cork layer; *ph*, phellogen; *wg*, wound gum.

The meristematic activity of the phellogen does not seem to extend to any parenchymatous cells of the vascular bundle. About the time of fall and after fall, a large amount of a brownish substance is produced in the separation layer and the cells adjoining, especially in the phloem. The brownish substance appears as globules as shown in Text-fig. 4. Tests show this substance is a kind of wound gum. No connection between the production of this gum and the resin canals was apparent. The break across the vascular bundle is brought about by gravity; no special devices are formed to cut off the exit of water from the tracheids and it is not for one season at least that the cork becomes thick enough to cover the broken end of the vascular bundle.



Taxodium distichum.

Text-fig. 5.—T.S. of a fresh branch scar showing the outlines of the protective layer and the remains of the separation layer along which region separation has been effected. Separation layer indicated by stencilling and cork by hatching. × 18.

This description has referred to the pruning off of foliar shoots. Sometimes larger branches are shed and distinct separation and cork layers are formed at the ends of the smaller twigs as well as the foliar shoots of these branches. The method of fall is exactly the same in the larger twigs as in the foliar twigs.

Other types were examined, but, as the material was collected in spring, very little fall was apparent in the evergreen types. In *Sequoia* and *Cupressus* the process seems to be very similar to *Taxodium*. In *Araucaria Bidwillii* the leaves, although cut off by a wide cork layer, remain persistent. The significance of this has not been established.

Lee (1911) has made a thorough examination of the morphology of the leaf fall in dicotyledonous Angiosperms. He finds that the fall is effected by a separation layer, protective layer and cork layer in some types in a very similar method to that described for the shoots of *Taxodium*. In other types the protective layers are partly secondary in origin, while in still other types the protective layer is totally secondary.

Seeing that the method of fall in the dwarf shoots of *Taxodium* is so similar to that of the common mechanism found controlling the fall of Angiosperm leaves, it does not seem that a detailed enquiry into the morphology of other types will give much result. The morphology of branch fall is very similar to that of leaf fall.

Section iii.

Very good evidence exists that branch fall took place among the microphyllous Lycopods of the Palaeozoic. Certain fossil stems, about 1 foot in diameter, known

as *Ulodendron* and *Halonia*, are found, the former of which has the characteristic leaf base markings of *Lepidodendron*, *Lepidophloios* and *Sigillaria* (Kidston), while the latter may have only *Lepidophloios* markings. In *Ulodendron* there are two rows of vertical scars alternating on each side of the stem. Each scar has a diameter of from 4 to 6 inches and is oval or round. It consists of a cup-shaped depression, in the centre of which is a small umbilicus, which is about one-fifth of the diameter of the scar. On the edge of the umbilicus there are spirally arranged prominent points, and radiating ridges on the rest of the cup-shaped scar. Plate xiii, fig. 8 is a photograph of a drawing of one of these scars from Scott's "Studies in Fossil Botany". Plate xiii, fig. 10 is a photograph of an impression of these scars found at Wallarobba, N.S.W., in Carboniferous beds.

This is a brief description of *Ulodendron*. The scars have been interpreted in several ways. Lindley and Hutton (1833), according to Watson (1914), suggested that they were cone scars and D'Arcy Thompson (1880) has actually described "cones" still attached. The scar was interpreted as resulting from the mutual pressure of the base of the cone and the stem while the umbilicus represented the point of attachment. This interpretation has been attacked principally on the grounds that it necessitates that the cones should be far larger than any known *Lepidostrobus* and also that in *Lepidodendron Veltheimianum* slender cones are known to have been borne on the ends of twigs, though this species has Ulodendroid scars. Lately this theory has been superseded by the view, originally suggested by Sternberg, that the scars were branch scars. Watson (1914) and Renier (1910) have elaborated this view. Renier considers that the umbilicus alone represents the point of attachment of the branch and the cup-shaped depression has been formed by mutual pressure between the branch and the main stem. Watson (1914) holds that the umbilicus represents the end of the vascular bundle and the rest of the scar the point of attachment of the cortical region. Watson gives very strong arguments against Renier's view and offers an abundance of evidence to prove his own.

Watson (1914) has described the formation of an abscission layer cutting off branches from several Lepidodendroid stems. The first of these specimens was a *Lepidophloios* which had lateral branches in two opposite rows—an arrangement which corresponds in position to the Ulodendroid scars. The structure of the stem resembled *Lepidophloios Harcourtii* and a thick layer of secondary tissue was formed at the base of the branch examined, cutting it off precisely as an abscission layer. This layer was nearly flat, but had a small depression in the shape of a conical pit on its outer surface round the stele of the branch. So in all points, in the arrangement of these scars and branches, in the details of the shape of the abscission layer and scar shape, a very close comparison is drawn. Watson (1914) says: "Although it is not certain that these actual examples were Ulodendra the occurrence of Cladopsis (branch fall) in a Lepidodendroid stem shows that we are justified in supposing that such a process occurred in *Ulodendron* when we have strong indirect evidence that such was the case".

Further evidence is supplied by the researches of M. Lindsey (1915), confirming this interpretation of *Ulodendron* and the occurrence of branch fall in the Lepidodendreae. Lindsey has discovered two specimens of *Bothrodendron minutifolium* in the Manchester Museum in which the nature of the branching and branches supports this view. The first specimen is a stem, the base of which broadens out into a trumpet-shaped body and ends quite suddenly in a clean convex edge. It was evident that this was not due to accident, but really was the

true end of the branch. The end corresponds exactly in diameter with the size of an ordinary Ulodendroid scar. The clean cut edge also was suggestive of an abscission layer.

The second specimen was larger and consisted of a stem with five lateral branches arranged alternately on opposite sides. The bases of these branches broadened into a trumpet shape. One of these, in fact, if cut off cleanly by an abscission layer at the base, would be identical with the first specimen and would leave a scar equal in size and shape to the Ulodendroid scar. *Bothrodendron minutifolium* so far has not been credited with possessing Ulodendroid scars, but Renier holds that *B. punctatum* and *B. minutifolium* are in reality one species, for there are only very slight specific differences in the leaf scar. Therefore, as *B. punctatum* is accredited with Ulodendroid scars, it is only reasonable to suppose *B. minutifolium* also possessed them.

Thus it seems fairly conclusive that branch fall existed among the Palaeozoic Lycopods and that Ulodendroid scars represent branch scars.

The Halonian stems are smaller in size as a rule, and are covered with *Lepidophloios* leaf-base markings and numbers of spirally arranged tubercles or knobs. These occurred as the ultimate branches of a dichotomously branched Lepidodendroid stem. The anatomy is Lepidodendroid. Plate xiii, fig. 9 is a reproduction of a photograph in Scott's "Fossil Botany" of an Halonian stem. These Halonian tubercles were interpreted as points of attachment of cones till Dr. Zalessky found that the cones of *Lepidophloios*, like those of *Lepidodendron*, were terminal on the extremities of branchlets and had no relation to the Halonian branch. It is apparent this interpretation must be rejected. In all probability these tubercles represent branch scars. Plate xiii, fig. 11 is a photograph of a branch scar on *Araucaria Cunninghamii*, and it is clear that in this case we have a close approximation to the *Ulodendron* scar.

In *Agathis Moorei* the scars on the trunk bear a very close resemblance to the Ulodendroid type. Unfortunately photographs could not be obtained.

Thus there is strong evidence that branch fall was a characteristic feature in the microphyllous Lepidodendreae. The significance of this in relation to the conifers will be made clear in the next section.

Section iv.

Before attempting to draw any general conclusions from the foregoing, it will be well to consider certain general principles. It may be said that the more ancient a family the greater is the rigidity of its members in phyletic characteristics. In this case rigidity of habit, external morphology and leaf form are specially referred to. This can be made clear by considering first the diversity of habit in the Angiosperms and comparing it with the uniformity of members of the more ancient groups of Pteridophyta and seed-plants.

In the Angiosperms the greatest variety of plant form exists. There are plants with the habit of ferns, and of Conifers, while in some trees the leaves are in whorls as in *Equisetum*. There is every possible variation in habit and size and shape of leaf. There is a great diversity of form in response to various physiological and ecological conditions. For example, the expression of xerophily can control the habit and leaf form of plants, producing characters in species and genera of no phyletic significance; yet these characters dominate the whole form of the plants.

Xerophily finds expression in many different ways. Often it is in leaf reduction or it may be in succulence. Leaf reduction may take either of two

forms, reduction in the size of the individual leaves or reduction in the total number of leaves. *Eucalyptus* may be taken as a good example of the latter, while many Leptospermums are good illustrations of the former. Again xerophily may express itself in excessive hairiness, but it is impossible to correlate the exact cause of xerophily with the expression manifested. Schimper says "the contrivances for conserving water . . . . appear to be identical in xerophytes growing in habitats where danger of desiccation is due to the most diverse causes. . . . That we have not here merely a case of accidental resemblance it may safely be inferred from the fact that many xerophytes are satisfied with physiological dry habitats of the most diverse kinds".

Xerophily may also find expression in a different manner in two closely allied species growing under conditions which seem to be identical. In *Hakea dactyloides* there has been a reduction in the number of leaves while the individual leaf surface has become reduced in most closely allied species, as *H. pugioniformis*, *H. acicularis*, etc. Many such instances could be given.

Again, in deciduous trees, leaf fall has been made periodic and annual to serve a purpose, and that is to combat an annually recurring period of drought or cold. In evergreens the foliage is being continually shed and renewed. The constant renewal of foliage whether periodic or continuous is a physiological necessity. Deciduous trees or tropophytes are xerophytes in their leafless condition and mesophytic as a rule with their foliage. When a dry or cold season alternates with a moist or hot one, tropophytes are abundant. In the north temperate zone, where a cold season alternates with a moist warm summer the trees are mostly deciduous in winter. Most plants of the flora of North and Central Europe are tropophytes.

In the tropics, where the hot dry season is the leafless season and is followed by wet seasons when the foliage appears, there are deciduous forests also.

So periodicity in leaf fall is an expression of xerophily especially adapted for circumstances in which the xerophilous conditions are periodic. It is an adaptation purely to climatic conditions and has no phylogenetic significance. There is no need to give further proof of this fact.

In some Angiosperms, where leaf reduction has taken place and the branches have become photosynthetic and serve functionally as leaves, they may be shed in the same manner as leaves. This seems natural. In *Casuarina* for example, the photosynthetic organs are short lateral switch-branches, which bear scale leaves in whorls. These lateral branches serve functionally as leaves and are shed as leaves. The same physiological controlling factor which operates in leaves operates in branches when these take over the function of leaves. This branch fall is not of any phylogenetic significance, as is the branch fall of the conifers, for in *Taxodium*, for instance, the foliar shoot is not photosynthetic and does not function as a leaf.

So in the Angiosperms, habit, leaf form and external vegetative morphology exhibit endless variety and have the closest relationship with various controlling physiological factors which render these features of no phylogenetic value. This has been illustrated by taking one feature only. Summing up: Xerophily expresses itself by many modifications in the habit and leaf form of the plant, producing great variety. These modifications may be very different in closely allied groups. Lastly there is no correlation in most cases between the cause of xerophily and the modifications in which the expression of xerophily is found. On the other

hand it does seem that the more ancient a phylum the more rigid it is in these respects, and therefore more stress should be laid on the external morphology of families of antiquity. In the Equisetales the habit of bearing leaves in whorls is a persistent feature. In all types from the ancient Calamite, *Archaeocalamites*, to the recent Equisetums whorled leaves and axillary branching are characteristic. The Equisetales were once a very large group, but never displayed any diversity in form comparable in the slightest with that found in the Angiosperms. In the case of the Equisetales the external morphology, habit and form of the plant are phylogenetically rigid.

In the Lycopodiales small leaves in spirals and dichotomous branching are practically general, except in the Selaginellaceae, which has assumed a dorsiventral habit. But no adaptations against drought or cold have resulted in leaf succulence or hairiness, etc., so common in the Angiosperms. Again the habit and small-leaved character are features of phylogenetic value or status.

In the Filicales an upright stem with a crown of large leaves is the more primitive condition. The dorsiventral habit of many modern ferns is considered the derived condition. But this is the only change. The Filicales remain an essentially megaphyllous class in which there are no succulent or deciduous forms.

The Pteridosperms seem to have arisen from a megaphyllous fern stock and have given rise to the Cycadales. Throughout these groups the habit is essentially the same. Excepting the Williamsoniales of the lower Mesozoic, the Cycadales are all characterized by a crown of large leaves and a main trunk which branches very rarely. The Cycadales at the present time have a wide distribution, but they have not responded to physiological and ecological factors by variations in leaf form and habit as the Angiosperms have done.

It seems clear that in these old groups external vegetative morphology is a character of great uniformity and phylogenetic rigidity in each class.

Bearing these facts in mind, the conifers may be considered from this point of view. The Coniferales are essentially a microphyllous group. It is generally held that they have been derived from a megaphyllous stock and that leaf reduction has been brought about by xerophily.

Now it has been shown that in the Angiosperms the expression of xerophily may take many forms, of which reduction in the individual leaf surface is one. Also it has been shown that there is no correlation between the expression of xerophily and the direct cause, whether it be physical drought or insolation, coldness of the soil or abundance of soluble salts in the soil or humus acids. In the nearest allied species, different expressions of xerophily manifest themselves under the same or similar conditions. It is therefore difficult to see how xerophily has but one expression in the Coniferales—that of leaf reduction.

The Coniferales are by no means restricted to a xerophytic habitat but occupy as many and as diverse situations as the Angiosperms. The Coniferales, like the more ancient groups described, exhibit a striking rigidity in leaf form and habit and for that reason it seems probable that the microphyllous habit is a palingenetic and not a coenogenetic feature.

Stopes (1907), writing on this subject, said: "It appears then that the xerophytic characters of the Coniferales in many cases are not adaptations to xerophytic conditions in their own lives nor are they inherited from the remote past as vestigial characters no longer in touch with present day necessities but are the result of physiological limitations of the type of wood in this ancient and incompletely evolved group. In other words their xerophytism is not oecological

but phylogenetic". Stopes came to this conclusion after considering the imperfection of the water conducting tracheids of the conifers in comparison with the vessels of the Angiosperms, and points out that the comparatively xerophilous nature of the conifers was due to this factor. This seems a very good explanation. It certainly accords well with the view that the microphyllous nature is phylogenetic.

If then the conifers arose from a megaphyllous ancestry, that ancestry is very remote indeed. It might be suggested that if the origin from a megaphyllous stock was granted, the assumption of an arboreal habit would induce microphylly in the same way as extreme ramification does. On the other hand there is no evidence to support this view. The smallest of the conifers, as *Microcachrys*, *Phaerosphaera* and *Dacrydium*, are very small leaved.

Warming (1909), criticizing Stopes's views, asserts that Conifers grow mostly on a physically or physiologically dry soil and in that respect are xerophytic to some extent. This does not seem to the writer to be connected with the actual question of microphylly. *Phaerosphaera Fitzgeraldi*, for instance, grows under the spray of waterfalls and, though "xerophytic" in that its leaves are very small, could not reasonably be termed a xerophytic plant.

The rigidity of the conifers is shown also in the fact that it is possible to trace the evolution of the foliar twig and of branch fall and that these are such characteristic features. The leaf form of the Abietineae is characteristic and, except for *Sciadopitys*, the Taxodineae would form a natural group almost on leaf character alone.

Further, the conifers form the evergreen forests of the north temperate zone. Except for *Larix*, *Taxodium distichum* and *Glyptostrobus*, the conifers are evergreen. This again illustrates the rigidity of the group and its inability to respond to ecological conditions as do the plastic angiosperms. In this way the conifers are far more comparable to the ancient phyla.

It has been stated by Mayer (recorded Schimper, 1903, page 51) that "the conifers appear to adapt themselves with more difficulty to a new climate than do broad leaved trees (Angiosperms)". This would be anticipated from our conclusions.

The Coniferales are rigid in vegetative morphology, comparable with the ancient groups of seed plants and Pteridophyta. The microphyllous habit of the conifers is palingenetic. It is very suggestive to find that, having arrived at this conclusion, the only other group exhibiting regular branch fall is the palingenetically microphyllous Pteridophytic stock of the Palaeozoic, the Lycopodiales. It should be noted that this subject has been viewed from one aspect only in this section.

Before Jeffrey (1917) promulgated his theory on the leaf gap of the conifers, it was believed that the affinities of the Coniferales lay in the direction of the Lycopodiales. A tremendous amount of weight has since been placed on the evidence of the leaf gap and, if this were to prove unsound, it seems very improbable that any objections to reverting to the old view of the affinities of the Coniferales could be raised.

Posthumus (1923) has put forward views on the subject in which he believes that the "leaf gap" of the higher seed plants is analogous to but not homologous with that of the larged leaved Pteridophyta. It remains to be seen whether these views will finally be accepted or not.

It is proposed to develop the avenue of research along these lines in subsequent papers. At present nothing more than a general account of the phenomenon has been given and the various considerations to which the inquiry leads pointed out.

Summary.

1. Branch fall is a characteristic feature of the Coniferales.
2. The development of foliar shoots and the associated shedding of branches can be correlated with the phylogeny of the tribes of the conifers.
3. It seems that the presence of distinct dimorphism in the branches of conifers is a primitive feature, and is gradually lost in the higher types.
4. The morphology of branch fall in *Taxodium distichum* is very similar to that of the fall among dicotyledonous leaves.
5. There is very good evidence that the shedding of branches was a feature of the Palaeozoic Lycopodiales.
6. Comparison with other groups indicates that the microphylly of the conifers is a palingenetic character, as in the Lycopodiales.

In conclusion the writer wishes to express his thanks to Professor A. A. Lawson for suggesting this problem and directing the research and to Assistant-Professor J. McLuckie for very material assistance in the preparation of this paper.

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EXPLANATION OF PLATES XI-XIII.

Photographs illustrating foliar shoots of conifers.

Plate xi.

Fig. 1.—*Pinus insignis* showing dwarf shoots.
Fig. 2.—*Cedrus deodara* showing dwarf shoots.
Fig. 3.—*Taxodium distichum* showing foliar or dwarf shoots.
Fig. 4.—*Sequoia sempervirens* showing dwarf shoots, which may grow forward into long shoots.

Plate xii.

Fig. 5.—*Chamaecyparis* showing branching and branch scars.
Fig. 6.—Showing the foliar branches of *Araucaria Bidwillii.*
Fig. 7.—Same as Fig. 6, showing scars along main lateral where foliar branches have been shed.

Plate xiii.

Fig. 8.—Reproduction of a drawing (after Scott) of *Ulodendron.*
Fig. 9.—Reproduction of a photograph from Scott's *Studies in Fossil Botany*, 1917, of a branch of *Halonia.*
Fig. 10.—Photograph of an impression of a Ulodendroid scar from Wallarobba, N.S.W., in Carboniferous beds.
Fig. 11.—Branch scar on the trunk of *Araucaria Cunninghamii.*

NEW AUSTRALIAN SYRPHIDAE [DIPTERA] IN THE BISHOP MUSEUM.

By C. Howard Curran and E. H. Bryan, Jr.
(Communicated by Dr. E. W. Ferguson.)

[Read 31st March, 1926.]

The following species of Syrphidae have been identified in a small collection from Australia in the Bishop Museum, Honolulu. Five species are here described as new. The apparent abundance of species of *Psilota* is noteworthy, as this genus is poorly represented in other parts of the world.

The types of the new species are deposited in the Bernice P. Bishop Museum, Honolulu; paratypes, where present, in the Curran collection, Ottawa, Canada.

A complete list of the species identified is as follows:

Triglyphus fulvicornis Bigot. Sydney, Oct., 1915 (J. C. Bridwell).
Psilota caerulea Macquart. Brisbane, Sept., 1915 (J. C. Bridwell).
Psilota cyanea Hill. Brisbane, Sept., 1915 (J. C. Bridwell).
Psilota auricauda, n. sp. Brisbane and Sydney (J. C. Bridwell).
Psilota erythrogaster, n. sp. (No data, J. C. Bridwell.)
Chrysogaster rufonasus, n. sp. (No data, J. C. Bridwell.)
Asarcina aegrota (Fabricius). Cairns, Q. (A. P. Dodd).
Epistrophe viridiceps (Macq.). Sydney (Illingworth, Helms, Bridwell).
Syrphus confrater Wied. Sydney, May 24, 1909 (Helms).
Sphaerophoria australensis Schiner. Cairns, Q. (J. F. Illingworth).
Sphaerophoria menthastri (Linn.). Sydney, Nov., 1915 (J. C. Bridwell).
Bacca siphanticida Terry. Cairns, Q. (Illingworth and A. P. Dodd).
Simosyrphus grandicornis (Macq.) (= *Xanthogramma grandicornis*). Wagga, Sept., 1904, and Bathurst, Oct., 1902 (Helms).
Lathyrophthalmus arvorum (Fabr.). Babinda, Q. (J. F. Illingworth).
Eristalis tenax (Linn.). Sydney (Helms and Illingworth), Macleay River (Helms).
Eristalis smaragdi Walker. Cairns, Q. (J. F. Illingworth).
Eristalis decorus May. Sydney (Helms and Bridwell), Brisbane, Sept., 1915 (J. C. Bridwell).
Eristalis flavohirta Klocker. Cairns, Q. (J. F. Illingworth).
Helophilus hilaris Walker. Cairns and Gordonvale, Q. (Illingworth).
Microdon nigromarginalis, n. sp. Brisbane (Bridwell), National R.R., Sept. 25, 1904 (Helms).
Cerioides subarmata, n. sp. Brisbane, Sept., 1915 (Bridwell).

The following new species are described by C. Howard Curran.

Psilota auricauda, n. sp.

Black, the apical two and one-half segments golden pilose. Eyes white pilose. Length 10 mm.

Female: Face slightly retreating, the oral margin not produced as much as the antennal base, densely grey pollinose, the cheeks shining black. Front

shining black, grey pollinose along the orbits on the lower fourth; strongly narrowed above. Occiput grey pollinose. Head with fine white pile, the upper fourth of the front with stronger black pile. Antennae brown, the first joint red at the base; the third obscurely reddish basally, hardly twice as long as wide, its upper apex rounded off. Arista black, as long as the antenna, tapering. The antennae reach the lower third of the face.

Pleura greyish pollinose. Mesonotum with a steel-blue reflection in some lights, the thorax white pilose.

Legs black; tibiae and tarsi shining brownish-red, the latter with the apical three joints black, the femora greyish pollinose, the coxae strongly so, the whole with conspicuous whitish pile. Posterior femora slightly swollen, their tibiae gently arcuate.

Wings hyaline, cinereous on the apical half; stigma brown. The apical cross-vein is oblique basally, roundly curved before its basal third and gently recurved before its apex so that it does not form a very acute angle with the third vein; discal cross-vein straight, oblique; the sector of the fourth vein beyond the discal cross-vein is three-fourths as long as the cross-vein. Spurious vein sub-obsolete. Squamae white, with narrow brown border and white fringe. Halteres pale yellow.

Abdomen shining black, the first two segments, and the broad sides, to the middle of the fourth segment, white pilose, the remainder with dense, erect golden-yellow pile.

Described from two females from Australia: Brisbane, Sept. 15, 1915, and Sydney, October, 1915 (J. C. Bridwell).

PSILOTA ERYTHROGASTER, n. sp.

Bright steel-blue, the abdomen reddish, the eyes white pilose.

Length 8·5 mm.

Female: Head, thorax and posterior femora steel-blue, the thorax with a purplish reflection. Face retreating, the oral margin prominent, but not produced as much as the antennal base; front narrowly grey pollinose along the orbits on the lower half; at the antennae not over one-fifth the width of the head, moderately narrowed to the vertex. Occiput thinly greyish pollinose, but along the orbits with dense greyish-yellow pollen. Pile of the head short, fine, whitish, rather dense along the lower frontal orbits, on the upper half of the front and the orbital cilia, black. Antennae light reddish, the third joint large, about one and one-half times as long as wide, moderately rounded off above; arista black, slender, tapering, as long as the antenna.

Thorax not pollinose, the pile short, sub-appressed, pale yellowish, perhaps a few black hairs above the base of the wings. Anterior coxae and prothorax grey pollinose.

Legs reddish, the posterior four femora blue, with obscurely reddish apices, the last two tarsal joints blackish; pile yellowish. Posterior femora moderately thickened, with black spinules below except basally, their tibiae gently arcuate and gradually thickened.

Wings hyaline, the veins yellowish or yellowish-brown; stigma luteous. Apical cross-vein oblique, slightly sinuous; discal cross-vein oblique, straight, more rectangular than usual. Spurious vein obsolete.

Abdomen dark reddish, with short, sparse, yellowish pile.

Described from a single female from Australia, bearing a greenish-blue label, but no data. J. C. Bridwell, collector.

Psilota rubra Klocker seems to be a distinct species; the antenna is described as brownish, the third joint blackish above, the hind femora black or only the distal half black, the hind tibiae brownish. There also seem to be differences in venation.

CHRYSOGASTER RUFONASUS, n. sp.

Head and thorax shining blackish-green, the abdomen opaque black with margin and apex shining; oral margin broadly red from beneath the middle of the eyes to the prominent anterior edge which is slightly more prominent than the antennal base.

Length 4 mm.

Female: Face, from the oral tip to the base of the antennae, scarcely one-fourth as long as the distance from oral tip to vertex very sharply excavated, thinly yellowish pollinose, devoid of hair except along the side pieces. Front wide, slightly narrowed above, twice as long as wide, clothed with fine, sparse, whitish pile. Occiput thinly greyish pollinose and short white pilose. Antennae reddish-yellow; third joint sub-orbicular, slightly wider than long, the arista longer than the antenna, thickened on the basal fourth, black on the basal half, reddish apically. Antennal pits broadly separated. Sides of front smooth, not at all wrinkled.

Pleura and anterior coxae thinly greyish pollinose. Thorax with very short, sparse, whitish pile. Scutellum rather narrowed to the apex, which is rounded, thus being somewhat triangular in shape.

Legs reddish, only the hind tibiae with a broad sub-apical brown band.

Wings slightly tinged with yellow, the veins yellow; stigma pale yellow. Both the apical and discal cross-veins are slightly oblique and rise at an angle, the fourth and fifth veins continuing towards the wing margin. Anterior cross-vein not more than twice its length from the base of the discal cell. Squamae white, with very narrow brownish border and very short brownish fringe.

There is a rather large, longitudinal reddish spot on the base of the abdomen at either side, but this is probably not normal, as it is more distinct on one side than the other. Pile very short, yellowish. All the segments of the ovipositor simple.

Described from a single female from Australia, bearing a blue label, but no data. (J. C. Bridwell.)

ASARCINA AEGROTA (Fabricius).

Eristalis aegrotus Fabricius, *Syst. Antl.*, 1805, p. 243.

Two females, Cairns, North Queensland (A. P. Dodd). Pupal cases.

EPISTROPHE VIRIDICEPS (Macquart).

Syrphus viridiceps Macquart, *Dipt. Exot.*, Sup. ii, 1847, p. 77.—? *Syrphus collatus* Walker, *Dipt. Saund.*, 1852, p. 233.

Sydney, N.S.W., Sept., 1902, Dec., 1903 (Helms), Oct., 1915 (Bridwell), Aug., 1921 (Illingworth).

SPHAEROPHORIA AUSTRALENSIS (Schiner).

Melithreptus australensis Schiner, Novara, p. 347.

A single male from Cairns, North Queensland (J. F. Illingworth), agrees perfectly with the description of the female as given by Schiner. The species is very close to and most probably identical with *Syrphus javanus* Wiedemann. The genitalia are much smaller than is usual in *Sphaerophoria* and the abdomen slightly wider.

LATHYROPHTHALMUS ARVORUM (Fabricius).

Syrphus arvorum Fabr., *Ent. Syst.*, iv, p. 286.

Male: Babinda, Q., 1920 (J. F. Illingworth).

MICRODON NIGROMARGINALIS, n. sp.

Head chiefly brownish-reddish; third antennal joint one and two-thirds as long as the first, which is short; mesonotum black, the margin and scutellum brownish, the pile on the latter silvery white, except on the margin where it is abundant, black, erect.

Length 11 to 12 mm.

Female: Face hardly one-third the head width, the front about two-fifths head width. Face brownish-yellow, convex-receding, most prominent just below the antennae, rather strongly convex transversely, the depressed sides white pubescent, the pile moderately abundant, silvery-white. Front brownish-red, the middle slightly depressed; a triangle reaching from the base of the antennae to the middle of the front and the small ocellar triangle, blackish; pile black, but whitish on the broad orbits below and across the middle. The occiput black, but the reddish of the vertex extends a short distance along the orbits, the whole greyish-white pollinose and white pilose; cheeks black behind. Antennae reddish-brown, with much of them reddish, but evidently variable, although the first joint is reddish, the third chiefly brown; first joint not more than two and one-half times as long as wide, gradually narrowing from apex to base; second joint two-thirds as long as the first, its apex not wider; third joint equal to or slightly longer than the first two combined, cylindrical or nearly so apically, narrowing to a rounded apex on the terminal third; arista about as long as the third joint, stout, tapering, brown, with reddish base. Eyes bare.

Mesonotum slightly shining black, with large, shallow punctures, the margin, except the wide anterior and narrow posterior, brownish-red; pile on the dark areas, except the broad anterior and narrow posterior margins, short black; on the margins, as well as on the pleura and scutellum, silvery-white. Pleura brownish-red, the scutellum concolorous; pectus largely darker. Scutellum with a broad apical fringe of up-growing black pile from the upper to lower margin; its apex broadly rounded, not emargined and without spines.

Legs brownish-red, the femora more or less black in front and behind, but variable in this respect and they may have only a black basal spot in front. Femora with short black hair, the tibiae with conspicuous appressed silvery-white hair except on the apical fourth of the hind pair.

Wings very broadly clouded with brown along the veins so as to leave only the middle of the cells hyaline. Anterior cross-vein separated from the base of the discal cell by less than its own length; stump of vein straight, oblique, rising just before the middle of the apical cell; both apical and discal cross-veins recurrent, with rounded bulge posteriorly. Squamae whitish, with yellowish border and fringe. Halteres reddish-yellow.

Abdomen brownish-black, the base and whole margin brownish-red, this colour gradually grading into blackish on the disc. Pile blackish, the whole lateral margin and broad, widely interrupted apical fasciae on the second to fourth segments with appressed silvery-white pile which is very conspicuous in some views; the fifth segment has the apical third similarly pale pilose, narrowly interrupted on the middle line and less widely so sublaterally. Sides of the abdomen subparallel on basal half, without depressions.

Described from two females from Brisbane, Q. (Bridwell). A third specimen labelled "National R.R., 25.ix.1904 (Helms)" has the antennae a little shorter and the scutellum a little more transverse apically. In this specimen the lengths of the antennal joints are as 4:2:7, while in the others they are as 4:3:8.

CERIOIDES SUBARMATA, n. sp.

Abdomen pedunculate; hind trochanters angularly produced postero-ventrally; scutellum yellow, with brownish base; face yellow, with brown median stripe and posterior half of cheeks.

Length 14 to 15 mm.

Male: Face yellow, a moderately broad median stripe, a broad transverse stripe below the antennae (narrowed at the sides), the cheeks and frontal triangle except at the sides, rusty brownish; in profile rather prominent on the lower half as the middle portion is raised, but again retreating to the oral margin. Eyes separated by a distance equal to the thickness of the antennal pedicel; vertical triangle rusty reddish, the upper part of the occiput of the same colour; along the orbits on the lower half yellow, elsewhere brown. Cheeks with a blackish stripe extending from the lower edge of the eye to the oral border, the latter blackish on the posterior half. Head with rather sparse yellowish pile. Antennae and pedicel rusty reddish, the latter as long as the face, the first antennal joint rather slender, three-fourths as long as the pedicel, the second joint almost as long as the first, cylindrical, widest apically, evenly narrowed to the base, the third joint about as long as the first two combined, strongly narrowed to its middle, thence slightly narrowed to its tip, the style weakly differentiated, more than one-fourth as long as the third joint.

Thorax granular, dull black, the humeri and a small spot at the outer end of the suture yellow, the area below the humeri and also below the base of the wing more or less ferruginous, the pile very short, white on the pleura and brown on the dorsum. Scutellum yellow with less than the basal half brown or blackish, its pile mostly pale and quite short.

Legs reddish, the hind femora with only the broad base and apex of this colour, the intervening space black, the anterior four femora black on the sub-basal half, but the hind surface wholly reddish or the black colour may be less extensive; hair of legs all whitish. Posterior trochanters produced as an angular projection, hind femora slightly arcuate, somewhat thickened, widest sub-apically, the tarsi broad.

Wings tinged with brownish; quite brownish on the anterior third; third vein moderately curved into the apical cell, the fourth vein curving around and back to join the apex of the discal cross-vein; anterior cross-vein slightly oblique, situated a little beyond the middle of the discal cell.

Abdomen dull black, the first two segments moderately shining, the narrow apices of the third and fourth yellow, the second reddish except an incomplete basal fascia and the apical third, opposite which the pile of the sides decreases in width until it reaches the apex, along which it extends inward a short distance. The second segment forms a slender peduncle which widens slightly from the apical third to the apex, the following segments forming an elongate oval; the first two segments are fused, there being only a more or less distinct suture. The terminal segments are cinnamon-brownish when viewed from in front, the rather large genitalia reddish or brownish-yellow. Abdominal pile chiefly whitish, but brown on the dorsum of the terminal two segments, longest on the sides and venter.

Described from three males from Brisbane, Sept., 1915 (J. C. Bridwell).

THE INFLUENCE OF CERTAIN COLLOIDS UPON FERMENTATION.

Part iii. Fuller's Earth and Aeration in the Alcoholic Fermentation.

By R. Greig-Smith, D.Sc., Macleay Bacteriologist to the Society.

[Read 26th May, 1926.]

The point was raised by Söhngen that the biocolloids such as paper, peat, charcoal and soil increased the fermentative activity of yeast by assisting the elimination of carbon dioxide from the fermenting fluid. At first sight this would appear very plausible for the fluids containing insoluble colloids such as talc do not hold much dissolved carbon dioxide. They do not foam freely when shaken and do not effervesce when thrown upon a filter. *Per contra* gelatinous solutions become highly charged with carbon dioxide and are not so much fermented as controls.

It occurred to me that if the colloid acted only as a carbon dioxide disperser, there should be no accelerating activity shown when, by the continued bubbling of air through the fermenting fluid, it was deprived of the gas. When the matter was tested it was found that the colloid had an effect of its own and did not act by virtue of its power of enabling the dissolved carbon dioxide to escape.

The test fluid contained 16 g. commercial dextrose, 10 c.c. yeast water, 0·2 g. peptone, 0·2 g. potassium dihydrogen phosphate and 0·1 g. anhyd. magnesium sulphate per 100 c.c. One of the flasks containing the fluid had 0·5 per cent. of fuller's earth.

The flasks were connected with an aspirator which caused sterile air to bubble continuously through the fluids. Each flask contained 250 c.c. of medium and was seeded with ten drops of a well distributed 20-hours' culture of a distillery yeast.

Table i.—The Influence of Fuller's Earth when air is aspirated through the fermenting fluid.

Days	2	3	4	5
Dextrose consumed, control	6·3	36·3	62·0	86·3
„ „ fuller's earth	7·2	40·5	68·0	88·6

There was little or no carbon dioxide dissolved in the fluids, as they did not effervesce when pipetted on to the filters previous to measuring off the portions for analysis; the aspiration had therefore effected its purpose. The influence of the colloid is evident and it is clear that it has, *per se*, an accelerating influence upon the activity of the yeast.

The experiment was repeated with 400 c.c. of medium of the same composition and with a heavier seeding of yeast of the same age.

Table ia.—The Effect of Aeration and Fuller's Earth.

Days	1	2	3	4	5
Dextrose consumed, control	24·7	29·3	58·3	80·8	90·5
,, ,, fuller's earth	26·4	46·6	77·2	89·7	91·1

The sudden slowing down of the control on the second day is peculiar and cannot well be explained. That it was not due to an experimental error is shown by the control overtaking the test on the fourth and fifth days. It is true that the air had bubbled faster through the control from the first to the second day, and this was done with the idea of eliminating the carbon dioxide quickly and so counterbalancing the gas-dispersing effect of the colloid in the other flask. The air that passed through the fermenting liquids came from the interior of the incubator and passed first through sterile cotton wool, then it bubbled through water in order to become saturated and so prevent any loss of water from the flasks. Obviously there could be no cooling of the control fluid to explain the reduced fermentation.

The experiments were confirmed in another way. Instead of aspirating air through the control and the test fluids, it was drawn through the control alone. Thus the dissolved carbon dioxide would be eliminated by the air in the control and by the colloid in the test. This did occur, for when the fermented fluids were filtered there was no effervescence.

Table ii.—The Influence of Fuller's Earth against an Aerated Control.

Days	1	2	3	4
Dextrose consumed, control, aerated	6·6	30·1	63·5	84·9
,, ,, fuller's earth, not aerated	7·4	39·8	74·4	88·9

It is clear that the elimination of the dissolved carbon dioxide is not the reason for the enhanced effect of the colloid upon the fermentation.

In the second experiment the possibility of the fermentation being depressed by the passage of air through the fermenting fluid was raised and to gain some definite idea as to this possibility a test was made. Three flasks were used. Air was passed slowly through the fluid, in one at the rate of one bubble every two seconds and in the second at the rate of four bubbles per second. The third fluid contained fuller's earth and was not aspirated. As before, the three fluids received the same volume of young suspended yeasts.

Table iii.—Slow *v.* Quick Aeration against Non-aerated Colloid.

Days	1	2	3	4
Dextrose consumed, control, slow aeration	6·4	31·2	59·5	84·4
,, ,, ,, quick aeration	7·2	32·2	60·2	84·8
,, ,, fuller's earth, no aeration	7·6	42·1	72·4	89·5

The experiment shows that the speed of aeration had little or no influence upon the rate of fermentation and could not have accounted for the slowing down of the control in Table ia from the first to the second day.

On comparing Table i with Tables ii and iii, it appears that aeration tends to lessen the difference between the control and the fuller's earth tests. The difference in Table i, where both flasks were aerated, is small compared with those of Tables iii and iv. Table ia cannot be compared owing to the break in the curve of the control.

So long as the fluid is aerated, it has been shown that the speed of aeration has little or no influence upon the fermentation. It is generally recognized that aeration assists fermentation in large volumes of liquid, but it is open to doubt if it also assists in small volumes, such as have been used in these tests, where the surfaces of the fluids are large compared with their depths. The matter was tested in a similar dextrose medium and it was shown that aeration did hasten the activity of the yeast.

Table iv.—The Aeration of the Fermenting Liquid.

Days	1	2	3	4
Dextrose consumed, fluid, not aerated	5·2	19·9	40·7	60·7
,, ,, ,, aerated	4·7	23·9	48·9	71·5

It is now evident that the results of Table i, in which both flasks were aerated, indicate the true effect of the fuller's earth. In Table ii, where the control alone was aerated, it is shown that the mineral colloid accelerates the fermentation more than mere aeration, and makes it clear that it does not act by virtue of its assisting in the elimination of the carbon dioxide.

Summary.—In testing the influence of the mineral colloids in the fermentation of dextrose, fuller's earth was used as a representative of the class. When the fermenting fluids were aerated, the colloid increased the consumption of sugar. When the control alone was aerated the colloid still increased the fermentation and it did not matter whether the aeration was rapid or slow. Aeration itself, under the conditions of the experiments, increased the speed of fermentation, but it was clearly shown that the colloid has an action of its own besides that of assisting in the elimination of the dissolved carbon dioxide.

REVISION OF AUSTRALIAN SYRPHIDAE (DIPTERA). PART I.

By E. W. FERGUSON, M.B., Ch.M., D.P.H.

(Plate xiv.)

[Read 26th May, 1926.]

Introduction.—The Syrphidae form a well defined group of Diptera which are distributed throughout the world. While, however, the family has been intensively studied in other faunal regions, as for example in Great Britain by Verrall, in America by Williston, in India by Brunetti and in the Malayo-Papuan region by de Meijere, little attempt has been made to deal systematically with the Australian species. The general impression has been that the Australian fauna is relatively poor in species as compared with other faunal regions, and this is probably in the main correct, though, as will be shown in the present review, the number of described species falls far short of the number occurring here.

The species already described are scattered through the works of Wiedemann, Macquart, Walker, Thompson, de Meijere, Bergroth, Klocker, Hardy and others.

Hardy (1921) made the first attempt at a critical revision of the previously described species, but his work was only partial, covering only the subfamilies Eristalinae, Cerioidinae, Microdontinae, Chrysotoxinae and Milesiinae. The extensive subfamily Syrphinae—the most abundantly represented—was not considered.

This work, partial as it is, has been of the greatest assistance to the writer of the present paper.

Klocker (1923) dealt with a small collection forwarded by the Queensland Museum and his material is entirely from that State. Curran and Bryan (1926) have recently contributed a short paper on material in the Bernice Bishop Museum, Honolulu. The present revision is rendered necessary by the chaotic state of the family, particularly in regard to the older described species of the subfamily Syrphinae and by the need of describing the many unnamed species that exist in all collections of Diptera. The revision follows more ambitious lines than has hitherto been attempted on the Australian members of the group, and it is the intention, not only to describe new species, but to review critically every species described or recorded from Australia.

The work has been considerably facilitated by a study of the writings of authors in other faunal regions, particularly those of Brunetti and de Meijere. A study of these was all the more necessary in that many species that are widespread in the Oriental region occur also in the tropical parts of Australia, in at least one instance as far south as Sydney.

Care has also to be taken to guard against describing as new, species which may have been introduced from Europe.

I have been helped greatly in the revision by the opportunities afforded of studying the species in the Australian Museum, Sydney, Macleay Museum, Sydney,

National Museum, Melbourne, Queensland Museum, Brisbane, and South Australian Museum, Adelaide, and my thanks are due to the authorities of these Museums.

I also wish to acknowledge my indebtedness to Mr. G. H. Hardy both for the loan of specimens from his extensive collection and for valuable suggestions and information. To Messrs. G. F. Hill, A. M. Lea, J. Mann, A. J. Nicholson and F. A. Perkins I am indebted for much material which would not otherwise have been available. Dr. I. M. Mackerras has helped me greatly in discussions of knotty problems and in the loan of specimens. To Professor M. Bezzi I am indebted for the identification of European and Oriental species occurring in Australia.

Family Syrphidae.

Head about as wide as thorax. Eyes ranging from bare to pubescent, sometimes in one sex only; facets in ♂ sometimes larger in front; generally contiguous or closely approximate in ♂, rarely wide apart (*Microdon*), always wide apart in ♀, always wider apart in ♀ than in ♂. Frons flush with eyes, moderately or strikingly prominent. Face variable, in the more usual form distinctly projecting beyond eyes in profile, usually distinctly cut away immediately below antennae, then produced into a central bump of varying size and shape, then retreating again and finally produced over upper border of mouth. Excavation below central bump often absent; the whole face sometimes conically and conspicuously projected forwards or diagonally downwards (*Graptomyza*). In some genera the face descends almost perpendicularly from below antennae (*Cerioides*); in others it forms a uniform convexity (*Microdon*). Antennae generally situated above middle of head in profile; normally comparatively short, drooping; in some genera the whole antenna is conspicuously elongate; arista dorsal, subbasal, bare to plumose; terminal style sometimes present (*Cerioides*). Proboscis short or moderately long, in rare instances extremely elongate (not in Australian forms); palpi one-jointed, slender, rarely conspicuous. Three ocelli present. Thorax quadrate, oblong, oval or sometimes transverse; moderately arched; generally with soft pubescence, occasionally with bristly hairs about lateral margins or corners. Scutellum moderately large, semicircular, rarely dentate at apex (*Microdon*).

Abdomen of at least four visible segments, sometimes five or six; variable in shape, curvature and thickness; sometimes longer and narrower than thorax (*Sphaerophoria*), ovate (*Syrphus*), flat and broad (*Didea*), linear (*Xylota*), cylindrical (*Syritta*), clavate (*Baccha*, *Cerioides*), short and rounded (*Criorrhina*). Genitalia usually not prominent, often wholly concealed, the ♂ organs normally twisted to right; in ♀ simple.

Legs usually simple and not strong, especially in ♀, occasionally the hind femora greatly thickened or bearing tooth-like or spiny processes; tibiae often curved. Wings with characteristic venation; Sc ending about middle of wing; R_1 and R_{2+3} long, slightly sinuous; cell R_1 (marginal cell) open or closed near margin; R_{4+5} always simple, in certain genera dipped downwards into cell R_5 (first posterior cell), sometimes with a rudiment of R_3 projecting into same cell; cell R_5 always closed by upturned section of M_{1+2}; median cell always present; apical section of M_{3+4} upturned, the apical portion of these veins generally parallel with hind margin of wing. Cross-vein r-m before, at, or beyond middle of median cell, erect or oblique; first basal cell always longer than second; anal cell always long, closed; a false vein or *vena spuria* always present (except in *Graptomyza*), sometimes very faint.

The above description of the characters of the subfamily is taken, slightly modified, from Brunetti (1923, pp. 23-5). The chief modification has been the substitution of the Comstock nomenclature of the veins. The family is considered by Brunetti to be allied to the Pipunculidae on the one hand and to the Conopidae on the other. Certainly the Syrphidae form a natural and well defined group.

Life History.—"The larvae are amphipneustic apparently acephalous, of about 11 uncertain segments, with rough skin, often pigmented, especially in Syrphinae; the posterior spiracles near together at tip of body. Puparium with thoracic spiracle-horns, and sometimes with smaller anterior horns that mark the position of the larval spiracles. Abdominal spiracles in pupa also prominent, much as in larva." (Brunetti, 1923, p. 25.)

Little is known of the breeding habits of Australian species; many species are aphidiphagous in the larval stage (*Syrphus*). The larvae of *Microdon* have been found in association with ants. Species of *Eristalis* live in drainage and have especially long extensile respiratory tubes—rat-tail larvae. One species of *Helophilus* breeds in rotting grass-tree stumps (*Xanthorrhoea*). Other species elsewhere live in decaying wood or vegetable matter, in the stems of plants or fungi, or the nests of Hymenoptera. Australian species of *Syritta* and *Eumerus* have been bred from fruit.

Subfamilies.—Various attempts have been made to subdivide the group into subfamilies. Even now there is no absolute concensus of opinion on the subject. Williston admits three subfamilies—Syrphinae, Eristalinae and Cerioidinae.

Brunetti, following Verrall, admits seven subfamilies—Syrphinae, Volucellinae, Eristalinae, Milesiinae, Chrysotoxinae, Microdontinae and Ceriinae.

Hardy admits six subfamilies as occurring in Australia, excluding the Volucellinae.

The Eristalinae, Microdontinae and Ceriinae or Cerioidinae constitute definite concepts sharply marked off from the Syrphinae. The position of the remaining subfamilies is open to question; in the Australian fauna at least the Milesiinae appear to form a natural group and are here retained. The Volucellinae, as far as *Volucella* is concerned, may constitute a natural group, but the separation from Syrphinae is broken down to a large extent by the inclusion of the genus *Graptomyza*, though Brunetti considers that the natural position of *Graptomyza* is in this group. In his key to the subfamilies, *Graptomyza* affords an exception to most of the characters used to separate the Volucellinae from the Syrphinae. The three characters cited in the key are the open or closed marginal cell, the apical section of fourth vein (R_{4+5}) not recurrent or recurrent, and the arista bare or plumose. *Graptomyza* differs from *Volucella* in the marginal cell being open, agrees with it in the recurrent vein, though this occurs in some genera (e.g. *Orthoneura*) of Syrphinae, and varies in the clothing of the arista. In regard to this last character Brunetti states (1923, p. 153) that a plumose arista is entirely foreign to the Syrphinae.

The general short ovate shape, produced epistome and plumose antennae would appear to be the main reasons for associating the genus with *Volucella* rather than with the Syrphinae. Whether the Volucellinae are entitled to subfamily rank is a question not to be debated here. It is tentatively included among the subfamilies represented in Australia in the key solely on the strength of the occurrence of *Graptomyza*. A peculiar feature of this latter genus is the complete

absence of the *vena spuria*. The presence of a system of chaetotaxy is also unusual in the family. The position of the Chrysotoxinae is almost as vexed a question. Brunetti, though placing the subfamily as distinct, states that it is "by no means a satisfactory one nor its position as such at all well established" (1923, p. 294). Verrall considered that *Chrysotoxum* would not be misplaced near *Syrphus* and *Xanthogramma*.

The subfamily as defined in Brunetti is characterized by the elongate porrect antennae with dorsal arista, rarely with apical style. The anterior cross-vein (r-m) is stated to be normally before middle of discal cell. The elongate antennae would thus appear to over-ride the position of the anterior cross-vein (r-m). Brunetti (1923) states, "The value of both the position of the anterior cross vein and the elongated or porrected nature of the antennae may be over-estimated, especially the latter". Williston (1908, p. 251) writes, "I cannot approve of such associations as *Psarus*, *Callicera*, *Chrysotoxum* and *Sphecomyia* in the subfamily *Chrysotoxinae*, distinguished chiefly by the elongate antennae. . . . . The length of the antennae is always doubtfully a generic character even, and certainly cannot be used as a distinguishing character for larger groups". In his table of genera, he includes *Chrysotoxum* both among the genera with anterior cross-vein distinctly before the middle of the discal cell, and among those with anterior cross-vein near or beyond the middle of the discal cell.

The question is debated here, as a species has been described from Australia as *Chrysotoxum elongatum* Hardy, which has the anterior cross-vein (r-m) beyond the middle of the discal cell (mc). While this species certainly has an elongate porrect antenna, other characters, especially the shape of the abdomen and the thickened hind femora, would appear to exclude it from the genus *Chrysotoxum*. Apart from the elongate antennae the species has the facies and structure of several genera referred to the Milesiinae and I propose to place the species in that subfamily as a new genus. Typical members of the genus *Chrysotoxum* have not so far been recorded or described from Australia and the subfamily is therefore omitted from the key.

Table of Subfamilies of Syrphidae represented in Australia.

1. Cross-vein r-m before middle of median cell 2
   Cross-vein r-m at or beyond middle of discal cell 4
2. Antennae short or moderately long, generally pendent 3
   Antennae porrect, generally long; venation peculiar .... *Microdontinae*
3. Marginal cell open; apical section of fourth vein (M_{1+2}) not recurrent (rare exceptions); arista bare or at most slightly pubescent .... *Syrphinae*
   Marginal cell normally closed (open in *Graptomyza*); apical section of fourth vein distinctly recurrent; antennae plumose (bare in some species of *Graptomyza*) .... *Volucellinae*
4. Antennae generally pendent, not situated on a petiole; arista dorsal subbasal 5
   Antennae long, porrect, generally situated on a prominent petiole; an apical style present .... *Cerioidinae*
5. Third longitudinal vein (R_{4+5}) distinctly looped into underlying cell .... *Eristalinae*
   Third longitudinal vein (R_{4+5}) at most slightly curved downward .... *Milesiinae*

The above key is based mainly on that given by Brunetti and where possible his wording has been given. Under this key the species described as *Chrysotoxum elongatum* Hardy will fall into the Milesiinae.

The genus *Dissoptera* Edwards cannot be placed in the key; it is provisionally included among the Eristalinae, but the position of r-m would exclude it from that subfamily.

Subfamily CERIOIDINAE.

CERIOIDES.

Ceria Fabricius, 1794, p. 277.—*Cerioides* Rondani, 1850, p. 211.—*Sphiximorpha* Rondani, 1850, p. 212.

Elongate wasp-like species characterized by the long porrect antennae, with terminal style, situated on an antennal tubercle or pedicel, which is usually long and cylindrical. First antennal segment long, cylindrical, second and third segments broad and flattened; face long and produced downwards, without definite tubercle, though somewhat humped above the oral margin; eyes contiguous in the male, widely separated in the female, bare. Abdomen elongate, more or less club-shaped, in some species greatly constricted at base, so that abdomen appears pedunculate. Wings with R_{2+3} bent forwards at apex to join costa; R_{4+5} with a more or less pronounced backward dip between r-m and the junction of R_{4+5} with M_1; M_{1+2} bent backwards at apex of mc; r-m oblique, situated beyond middle of mc; *vena spuria* well marked.

This genus—the sole member of the subfamily—is represented in Australia by a moderate number of species, most of which have been undescribed up to the present. Hardy (1921, p. 13) records three names as applying to Australian species, but is doubtful of their allocation; he also mentions having four species under examination.

Macquart (1850, p. 128) described and figured *Ceria australis*, recording the species from Tasmania. The question of the identity of this species is discussed later.

Saunders (1845) described two species, *Ceria ornata* and *Ceria breviscapa*, both of which have been recognized in the material before me

Curran and Bryan, in their recent paper (1926) published in these Proceedings, describe a new species—*Cerioides subarmata*—of which a paratype is before me. In the present paper, nine new species are added to the genus, five of them being allied to *C. ornata* and four to *C. subarmata*. The genus as represented in Australia is divisible into two main groups on the structure of the abdomen; in *C. ornata* and its allies the abdomen, though narrower at the base, is not greatly constricted as in *C. breviscapa* and other species. *C. breviscapa* is separated from all other species by reason of the very short antennal tubercle or pedicel.

Distribution.—The genus so far as at present known is principally distributed along the eastern portion of Australia and is richest in species in Queensland. Thus of the twelve species known (excluding *C. australis*, of which both identity and habitat are doubtful), *C. ornata* occurs from N.W. Australia, through Queensland into N.S. Wales; *C. variabilis* in Queensland and probably N.S. Wales; *C. apicalis*, *C. alboseta*, *C. macleayi*, *C. subarmata*, *C. doddi* and *C. facialis* are known only from Queensland; *C. platypus* from Queensland and S. Australia; *C. mastersi* from S. Australia; *C. opuntiae* from N.S. Wales, while *C. breviscapa* occurs in N.S. Wales, South Australia and probably Victoria. Thus Queensland has nine species, as against four from N.S. Wales, one from Victoria and three from S. Australia. No species are known from Western Australia (excluding N.W. Australia), but as the family has not been extensively collected there, it is quite possible that species of this genus will ultimately be found in that State. The fact that so many of the species are represented by single specimens suggests that many more species still await discovery, especially in the tropical parts of Australia.

It should be noted that Brunetti (1923, p. 323) retains the name *Ceria* in preference to *Cerioides*. This is not the place to discuss the question and I prefer to use the more generally accepted nomenclature.

Table of Species of Cerioides.

1. Basal abdominal segments not greatly constricted 2
   Basal abdominal segments constricted, i.e., abdomen pedunculate 7
2. Second abdominal segment with elevations and depressions 3
   Second abdominal segment with even surface 5
3. Basal abdominal segments mainly black, at most with reddish apical margin to second segment 4
   Basal abdominal segments largely reddish ...... *ornatus* Saund. ? *australis* Macq.
4. Posterior femora normal in both sexes .... *opuntiae*, n. sp.
   Posterior femora thickened and flanged in ♂ .... *platypus*, n. sp.
5. Third and fourth abdominal segments with subapical elevations; style white .... *alboseta*, n. sp.
   Third and fourth abdominal segments with even surface 6
6. Costal cell infuscated; third abdominal segment black with apical band; (in ♂ third abdominal segment shorter than fourth) .... *variabilis*, n. sp.
   Costal cell clear; third abdominal segment reddish-orange with a triangular basal area black (in ♂ third abdominal segment longer than fourth) ..... *apicalis*, n. sp.
7. Antennal tubercle very short .... *breviscapa* Saund.
   Antennal tubercle long, cylindrical 8
8. Dark anterior margin of wing not extending into dip of R_{4+5} 9
   Dark anterior margin of wing including dip of R_{4+5} 10
9. Second abdominal segment largely reddish; thorax subvittate; (in ♀ lateral frontal porose areas present) .... *macleayi*, n. sp.
   Second abdominal segment black with narrow yellow margin; thorax not vittate; (frontal porose areas absent in ♀) .... *doddi*, n. sp.
10. Second abdominal segment with constricted portion very short, width at apex nearly equal to third abdominal segment .... *mastersi*, n. sp.
    Second abdominal segment with longer constricted portion, width at apex much narrower than that of third segment 11
11. Antennal tubercle as long as first and second antennal joints combined (♂ unknown) .... *facialis*, n. sp.
    Antennal tubercle shorter; (♂ with eyes separated, posterior trochanters tuberculate, and posterior femora incrassate) .... *subarmata* C. & B.

Cerioides australis Macq. is doubtfully bracketed in the table with *C. ornatus* Saund. since it is probable that both names apply to but one species.

CERIOIDES ORNATUS (Saund.).

Ceria ornata Saund., 1845, p. 64, Plate 4, fig. 3.—*Cerioides ornata* de Meijere, 1908, p. 197; Hardy, 1921, p. 13.

I believe that this name should apply to a fairly common and widespread species which is variable in the coloration of the second and terminal abdominal segments. In the majority of the specimens before me, which are mostly males, the first segment is black with rufous sides, and the second rufous with a more or less extensive black patch in centre, while, as a rule, the posterior margin of the second segment is bright yellow. In one male from Sydney the margin is rufous like the rest of the segment, the black patch being practically non-existent, and in a female from Gayndah, the same coloration occurs. In most of the specimens the fourth segment is black with rufous or yellow margin and dusted over with yellow, to a greater or less extent in different specimens; in the above-mentioned female, the clothing is very dense and bright golden in colour.

In his original description Saunders, as mentioned by de Meijere, has taken the first and second segments together as one, and describes it as "rufous, margined with yellow posteriorly and stained with dusting on upper basal side", while the fourth joint, wrongly named the third is described as "rufous . . . . with a yellow posterior margin". This would fit the Gayndah female fairly well, except that the margins are rufous rather than yellow. I suspect, however, that the yellow may darken to rufous with age. This species would appear to be the

same as that commented upon by Hardy under this name. "*Cerioides ornata* Saunders has the first segment of the abdomen only slightly constricted. . . . Two species exhibit this character, and one of these has a pair of callosities on the second abdominal segment. It was found labelled under Saunders's name, and is represented by specimens from Queensland and New South Wales". All my specimens show a distinct swelling on either side of the middle line, the latter being somewhat depressed; the apical margin of this segment is also raised.

I am, however, doubtful if the *Cerioides ornata* redescribed by de Meijere is the same species, the second abdominal segment being from the description black with a yellow border and the extreme posterior edge black. This would appear to fit *C. variabilis* as does also the smaller size. De Meijere also mentions that the two inner golden flecks on the fore border of the thorax are absent in his specimens; they are distinct on the species I regard as *C. ornata*, but not on *C. variabilis*.

Hab.—N.W. Coast (type); North Coast, N. Holland (one old specimen in Macleay Museum), Melville Island (S. Australian Museum); Queensland: Cape York, Claudie R., Endeavour River, Cairns, Stewart River, Pt. Denison, Rockhampton, Eidsvold, Yeppoon, Westwood, Gayndah; N.S. Wales: Sydney.

Twenty-four specimens of this species, including both sexes, are under examination.

CERIOIDES AUSTRALIS (Macq.).

Ceria australis Macquart, 1850, p. 128; de Meijere, 1907, p. 198.—*Cerioides australis* Hardy, 1921, p. 13.

The description of this species closely agrees with that of *C. ornatus* Saunders, with the exception that the first antennal joint is described as being as long as the prolongation of the head on which it is situated. The figure given by Macquart shows the same feature. If this is correct the species is unknown to me, but I suspect that a mistake has been made and that the species is the common one herein regarded as *C. ornatus* Saunders. It may be noted that Hardy mentions that no species of the genus exists in recent collections from Tasmania, but it is quite likely that the locality is wrongly stated, as is the case of several other descriptions of diptera in the same part of Macquart's work.

CERIOIDES OPUNTIAE, n. sp.

Male. Head black; eyes contiguous for about one-seventh of head width, vertex black with a yellow spot on each side, frontal triangle yellow, dark brown around root of antennal tubercle, orbits white tomentose; face yellow, with broad median dark brown stripe, vertical sides black; cheeks black; posterior orbits white tomentose; antennal tubercle dark brown, shorter than usual, but longer than in *breviscapa*, the first antennal joint very slightly longer than tubercle, second joint about half length of first; third joint not quite as long as first, all the joints blackish-brown, style short, dark. Mesonotum black, rather closely granulate; a yellow spot on humeral angle, an obscure reddish-brown mark between humeral angle and suture. Scutellum reddish-brown, yellowish at base. Pleurae black with a yellow spot on posterior half of mesopleuron. Abdomen not constricted at base; first and second segments black, rather coarsely granulate, second with an oblique impression on each side from midline at base to near apex at lateral margins, the posterior margin somewhat raised; third black with rather broad yellow apical band, the segment somewhat longer than second, a well marked transverse impression present on each side near middle; fourth

segment long, nearly twice length of third, black, with a small triangular yellow patch at apex, pubescence short, appressed, mainly pale. Venter black. Legs with coxae and basal two-thirds of femora black to blackish-brown, the apical third of femora reddish-brown, tending to yellow at knees, tibiae yellow to reddish-brown, becoming infuscate in apical third; tarsi dark, moderately flattened; posterior femora not dilated or incrassate, some short spines on ventral margin in apical third.

Wings mainly hyaline, a narrow dark band extending from base to near apex, leaving clear the costal cell, the whole of cell R_3, except extreme base, and the apical third of cell R_1, except that the extreme apex of vein R_{2+3} is suffused on each side. Calypters whitish with yellow border; halteres yellow.

Length, 8 mm.

Hab.—New South Wales: Cuttebrai Creek (Burrows, August, 1917, bred from decaying prickly pear), Biniguy (J. Mann, March, 1923), Nevertire (March, 1926).

Type from the collection of the Government Entomologist, Department of Agriculture. In the paratypes the transverse impression on the third segment is hardly traceable; in other respects the specimens agree.

The species is the only one I have seen in which the antennal tubercle and the first antennal joint are nearly equal; at first sight they appear so, but on actual measurement the first joint is slightly longer. The species, however, can hardly be *C. australis* Macq., since the descriptions of the abdominal segments and of the wing markings do not fit *C. opuntiae*, whereas they do agree with *C. ornatus* Saund.

Type presented to the Macleay Museum.

CERIOIDES PLATYPUS, n. sp.

♂. Head similar to *C. variabilis*, the vertical and ocellary region darker brown, the facial stripe less dilated around antennal tubercle, but with cross-line more evident so that the dark markings are distinctly cruciform; cheeks entirely dark; second antennal joint longer than third and approximately equal to first joint; style broken. Mesonotum black, without yellow markings, the surface set with minute granules, the humeral and post-alar prominences dark reddish-brown, sublaevigate; inner end of suture reddish-brown; pubescence pale. Scutellum yellow with broad apical black marking. Pleural segments black with a yellow patch on posterior portion of mesopleuron. Abdomen not greatly constricted at base, the first segment black, the second longer than first, black with a broad apical reddish-orange band occupying almost half the segment, but slightly narrower at sides, the basal portion of segment raised slightly on each side; third and fourth segments black with orange posterior border; third segment slightly longer than fourth, longer but not greatly wider than second; pubescence mainly yellow on all the segments. Venter black with pale segmentations and clothed with very long pale straw coloured silky pubescence. Legs reddish-brown, the coxae, basal two-thirds of femora with exception of extreme base of femora, tarsal segments with exception of first segment, dark brown; posterior femora greatly thickened, with a flange-like projection on apical third of antero-ventral margin; posterior tibiae bowed, the ventral surface bisinuate; tarsal joints, including metatarsi, flattened, short and greatly widened; the posterior metatarsi longer and less noticeably widened; pubescence on legs pale straw coloured and distinctly longer than in other species, the ventral surface of intermediate tarsi with especially long pubescence; a patch of short black stiff setae on flanges of

posterior femora. Wings clear with dark brown anterior margin limited posteriorly as in *C. variabilis*. Halteres yellow; a bright yellow knob present at base of abdomen behind halteres.

♀. Similar, head as in *C. variabilis*, but dark band on front extending over ocellary region and vertex, and facial stripe cruciform; antennae dark brown, third joint and style lighter; first joint longer than second, the latter approximately as long as third. Thorax as in ♂, but inner portion of transverse suture clothed with golden tomentum (traces of this are present in the ♂); abdomen similar in colour, but fourth segment rufous yellow with bright reddish-orange margin; third segment noticeably wider than second and considerably longer than fourth; posterior femora normal, without flange, the tarsi less dilated, though broader than normal, the whole legs reddish-brown, only slightly darker on tarsal segments.

Length, ♂. 12·5, ♀. 11 mm.

Hab.—S. Australia; holotype and allotype without exact locality in Australian Museum collection (K 36977). Queensland: Magnetic Island (A. M. Lea, S. Australian Museum).

The ♂ of this species can readily be distinguished by the femoral and tarsal structure. The ♀ differs from *C. ornatus* in the first abdominal segment being entirely black and from *C. variabilis* also by the structure of the second segment, and the broader tarsal joints.

CERIOIDES ALBOSETA, n. sp.

♂. Head similar to *C. variabilis*. but with median dark vitta not reaching mouth margin, lower margin of vertical sides of face more extensively yellowish; cheeks with more pronounced silvery pubescence and tomentum; antennae similar, but first joint about equal in length to second, the remaining joints broader than in *C. variabilis* and with a conspicuously white style. Mesonotum as in *C. variabilis*; scutellum yellow with dark base; pleura with large yellow spot involving the greater portion of mesopleuron. Abdomen coloured much as in *C. variabilis*; first segment reddish-yellow with lighter yellow side margins; second segment black with indications of a subapical transverse band; third segment slightly longer and wider than second, but considerably shorter than fourth, black with reddish-yellow apical border; third and fourth segments each with a low but conspicuous hump in midline near posterior third, the fourth segment slightly depressed on each side of elevation and with a subapical transverse sulcus, black with rather narrow reddish-yellow apical border. Legs as in *C. variabilis* with silvery pubescence on coxae more conspicuous. Wings coloured as in *C. variabilis*.

Length, 10 mm.

Hab.—Queensland: Gordonvale (December, 1919), Cairns District (Dodd), Port Curtis (Macleay Museum), Somerset (S. Australian Museum).

While closely allied to *C. variabilis*, the difference in the antennal joints and the presence of the protuberances on the third and fourth abdominal segments prevent me regarding it as the same species.

Two specimens (♂, ♀) in the Queensland Museum belong to this species. The ♂ (Brisbane) has the face all yellow, the median stripe and dark of lateral areas being merely indicated by being semitransparent; the general colour is brighter yellow and the apical band on second segment more distinct. In the ♀ (no locality) the eyes are separated by one-sixth of total head width, the front is reddish-yellow with a darker brown patch on each side anteriorly; the band

on second abdominal segment is clear yellow and well defined and the third abdominal segment is distinctly longer than the fourth; on the latter segment the median prominence is almost obsolete. Length, 11 mm.

CERIOIDES VARIABILIS, n. sp.

? *Cerioides ornatus* de Meijere (1907), *nec* Saunders (1845).

♂. Eyes bare, meeting in middle line along anterior third of inner margin; ocellary triangle reddish-brown, yellow in front; frontal triangle and face bright yellow with a median dark brown stripe, widened around the antennal tubercle, sometimes with an obscure extension to eye margin on each side; antennal tubercle cylindrical, reddish-brown; lateral portion of face black, shining, cheeks narrow, black with brown border; occiput black, reddish-brown above, the posterior margin of eye clothed with whitish tomentum becoming golden on upper portion. Antennae dark brown, the apical joints somewhat lighter, first joint about two-thirds length of antennal tubercle, second joint shorter and wider than first, third joint about as long as second. Mesonotum black, set with small granules, finer and closer on posterior portion; humeral tubercles bright reddish-yellow, a similar prominence present on lateral margin in front of suture and a patch of golden pubescence present in suture at inner end. Scutellum bright yellow with brownish-red apex and sides, laevigate with sparse granules. Pleurae black, with or without a reddish-yellow spot on mesopleuron. Abdomen not markedly constricted at base; first segment rather closely granulate, depressed in midline at base, reddish-brown with an indefinite median black mark posteriorly and reddish-yellowish side margins; second segment entirely black, the surface even without depressions or elevations, about as long as first; third black with bright reddish-yellow posterior border, longer and broader than second; fourth black, slightly suffused with rufous posteriorly and with a reddish posterior margin, strongly convex and longer than third segment; pubescence short, black on dark areas, pale yellow on lighter and on greater portion of fourth segment. Venter black with narrow pale segmentations. Legs reddish-brown, yellowish on trochanters and extreme base of femora, knees and basal third of tibiae; base of anterior and middle femora darker; posterior femora not abnormally dilated, with some spinose setae on ventral surface in apical portion.

Wings clear with anterior portion broadly and deeply infuscate, the dark portion bounded by the *vena spuria* in basal two-thirds and by R_{4+5} in apical third; venation normal. Halteres yellow.

♀. Eyes separated. Posterior portion of front and vertex bright reddish-yellow, with a broad black transverse band behind antennal tubercle; third antennal joint longer than second. Thorax as in ♂. Second abdominal segment black with a subapical reddish-yellow band, slightly wider in centre and separated from extreme edge by a narrow dark border; third segment considerably longer than fourth; fourth segment more extensively reddish and with denser tomentum. Length, 10 mm.

Holotype and allotype and paratopotype ♂, Westwood, Queensland (Goldfinch, 10·23); paratypes ♂, ♀ Eidsvold (Mackerras), ♀ Gayndah (Australian Museum), ♂, ♀ Rockhampton, ♀ Port Curtis (Macleay Museum).

A series of 12 ♂ and 18 ♀ of this species are under examination. Despite the difference in the banding of the second abdominal segment and the difference in the length of the third abdominal segment in the two sexes, I have no doubt that the sexes belong to but one species.

This is probably the species redescribed by de Meijere under the name of *Cerioides ornatus* (Saund.), but it does not agree with the original description as well as the species identified as *C. ornatus* in this paper.

The pleural patch is absent in the types and in certain other specimens, but every grade in size can be found between a large conspicuous patch and complete absence.

Two females in the collection of Mr. J. Mann, Brisbane, may represent extreme varieties of this species; in one specimen the band on the second segment is absent, the third segment is almost entirely orange, as is also the fourth; in the other the subapical band on the second segment is present as in normal specimens, but the orange colour of the third is largely increased, though not to the same extent as in the first specimen.

CERIOIDES APICALIS, n. sp.

♂. Head black; a small spot on each side of forehead external to antennal tubercle and a large patch on each side of midline of face extending to eye margin, yellow, the lower portion of face, excepting midline, and the lateral black areas on each side of antennal tubercle clothed with white tomentum, similar tomentum also present along the margin of eye; pubescence scanty, whitish, longer on posterior inferior angle of head; eyes bare, meeting for a short distance in midline. Antennal tubercle dark brown, long. Antennal joints dark brown, first shorter than tubercle, second joint as long as first, but wider, third joint shorter, apical joint dark.

Mesonotum black, finely granulate, a small golden tomentose spot on each side of midline at inner end of transverse suture; humeral angles slightly shining with well marked reddish-yellow tooth at upper and outer corner. Scutellum black, slightly shining, the posterior margin pale brown, surface less closely granulate than on mesonotum. Pleural segments with whitish tomentum.

Abdomen not constricted at base, three basal segments black, the extreme apical portion of second segment narrowly reddish; third segment with large black patch extending from base to middle of segment in midline and narrowed to half that width at sides, rest of the segment bright orange; fifth segment orange, yellowish at base; under surface black; pubescence black on dark areas of dorsum, yellow on orange areas; longer and white at sides and on under surface.

Legs black, the extreme apices of anterior and middle femora and the apical third of posterior femora reddish-brown; extreme apices of the anterior and intermediate tibiae, the whole of the posterior tibiae and of the tarsi reddish-brown.

Wings clear, with a dark brown band extending along the anterior margin, except in subcostal cell, the posterior margin bounded by Cu_1 as far as discal cell, by *vena spuria* as far as r-m, and thence by R_{4+5}.

Length, 11 mm.

Hab.—Queensland: Gayndah (G. Masters).

A single specimen in the collection of the Australian Museum.

This species is most closely allied to *C. variabilis*, n. sp., but, *inter alia*, differs in the very large third abdominal segment which largely conceals the fourth, whereas in the male of *C. variabilis* the fourth is actually longer than the third, though in the female the third segment is considerably longer than the fourth. The colour pattern is also different, and the brown of the wings is absent from the subcostal cell, and extends further posteriorly as described; in

variabilis the whole of the subcostal cell is dark and the dark border is limited posteriorly by the *vena spuria* and thence by R_{4+5}; in both species a small portion of the first basal cell anterior to the false vein at the extreme apex of the cell is clear.

CERIOIDES BREVISCAPA (Saund.).

Ceria breviscapa Saunders, 1845, p. 65, Pl. 4, f. 5.

This species is readily distinguished by the short and comparatively wide antennal tubercle; the facial marking is distinctly cruciform and the vertical sides of face entirely dark; the first antennal joint is somewhat shorter than the remaining joints; the mesonotum is black with reddish-yellow or yellow humeral angles, presutural callus, posterolateral border and scutellum; there is no pleural spot. The abdomen is constricted at base, the first segment, which is black, being evenly decreased from base to apex, while the second, which is black at base and reddish-yellow at apex, is narrow in basal half and thence suddenly widened to apex; the two joints are subequal; the remaining segments are black with apical reddish-yellow bands. In the wings the brown anterior border is bounded posteriorly by the *vena spuria* as far as the r-m cross-vein, thence by R_{4+5}, including the dip in the latter which is less deep than usual; Cu_1, m-cu, and M_{3+4} are also shaded.

In the female the lateral areas in front are rugosely sculptured, though not deeply punctate, also the second abdominal segment may be entirely reddish-yellow as in a female from Ropes Creek, whereas in another female from Mittagong the reddish-yellow is replaced by a yellow band at apex. In this specimen also the apical bands on the third and fourth segments are first reddish-yellow and then yellow, while the scutellum is stained with blackish at base. In a male from South Australia only the humeral angles and scutellum are yellow; while the reddish-yellow markings on abdomen are clear yellow, the dark markings on face are less cruciform in shape.

Hab.—N.S. Wales: Ropes Creek, Mittagong, Toronto; S. Australia.

I think there can be little doubt that the specimens before me are correctly identified; the only particulars in which they differ from the original description are that there are only two (i.e. on the humeral angles) not three yellow spots on anterior margin of thorax and that the scutellum is not dark brown. It is to be noted that in one specimen the scutellum is blackish-brown at base. The first and second abdominal segments have been taken together as the first in Saunders's description. The type is stated to be from Port Phillip, S. Australia; probably Port Phillip in Victoria (Melbourne) is intended.

CERIOIDES MACLEAYI, n. sp.

♂. Head yellow, median line of face from mouth margin to antennal tubercle, and a broad band on upper portion of the vertical sides of face dark brown; cheeks yellow; occipital region blackish, yellowish-brown above; vertex blackish around ocelli; antennal tubercle long, light brown; antennae darker, the first joint shorter than tubercle, longer than second joint, the latter very slightly longer than third. Mesonotum blackish, humeral angles yellowish, a yellowish-brown mark extending backwards on each side from humeral angle to beyond transverse suture; a second similar but a narrower line from near transverse suture to posterior margin somewhat internal to first line, the posterolateral borders and an oval spot on each side of midline at posterior margin yellowish-brown; surface of mesonotum finely granulose. Scutellum yellowish-brown with black sub-

triangular patch in middle. Pleural segments black, a large yellowish patch extending over posterior portion of mesopleuron and covering adjacent portions of the sternopleuron and pteropleuron.

Abdomen greatly contracted at base, wasp-like; first segment narrowed from base, rather closely punctate, second long, narrowest in basal third and widened slightly to apex; sublaevigate at base, closely punctured from middle to apex, the remaining segments of the abdomen much wider and elongate, together forming an egg-shaped mass; the third and fourth segments about equal in length; first and second segments reddish-brown, paler at base and apex of second segment; third segment black with yellow-brown band at apex; fourth segment black with yellowish apex, the whole segment rather densely clothed with long appressed yellow pubescence. Under surface with basal segments yellowish-brown, remainder black.

Legs reddish-yellow, the extreme bases of the anterior and middle femora and the basal half of posterior femora somewhat darkened, the posterior femora not greatly thickened, but with rather numerous small spines along under surface in apical half.

Wings clear with broad vitta along the anterior margin extending back as far as *vena spuria* to opposite base of median cell; from thence as a more or less straight line to above apex, leaving unshaded the whole of the apical portion of the first basal cell and the dip of R_{4+5} into the first posterior cell.

♀. Similar to male. Front with a broad transverse dark band in the midline forming a laevigate carina, on each side of which is a closely punctate or porose area, the punctures not being continued to eye margin; second and third antennal joints subequal.

Length, 8-10 mm.

Hab.—Queensland: Rockhampton, four males and two females in the collection of the Macleay Museum; Brisbane (12.11.12), a female in the Queensland Museum.

CERIOIDES DODDI, n. sp.

♀. Closely allied to *Cerioides macleayi*. Face yellow, with median vitta broader; vertical sides black, except on lower borders, cheeks yellow with white tomentum; forehead with a transverse black band extending across the forehead behind antennal tubercle; ocellary region black leaving a pair of yellow spots between that and the transverse black band of forehead; antennal tubercle long, dark brown; antennae dark brown, apical joints lighter, first joint but little shorter than the tubercle and twice the length of the second joint, the latter slightly shorter than the third joint, style dark.

Thorax black with yellow humeral angles, a yellow spot on lateral border in front of transverse suture and yellow-brown posterolateral borders; indistinct yellow pubescence along the transverse suture. Scutellum yellow with black band at base; surface of mesonotum and basal portion of scutellum closely granulose. Pleural segments black with yellowish spot on mesopleuron extending on to sternopleuron, but not on to pteropleuron.

Abdomen greatly contracted at base, wasp-like; first segment narrowed to apex; second segment about equal in length to first, narrow at base, widened to apex, narrowest portion of abdomen at junction of two segments, both segments granulose; remaining segments elongate-ovate, much wider; basal segments black with yellow band at apex of second segment; third and fourth segments black with yellow band at apex of each; the two segments about equal in length, the fourth

segment with somewhat appressed yellowish pubescence in apical half; fifth segment black; under surface black.

Legs reddish-brown, the knees and basal portions of the tibiae and the extreme apex of the anterior tibiae bright yellow. Tarsi slightly infuscated, specially on the terminal joints. Posterior tibiae not greatly thickened, spinose below in outer half.

Wings clear, with dark brown anterior margin as in *C. macleayi*.

Length, 13 mm., second female, 11 mm.

Hab.—Kuranda, Queensland (Dodd).

While closely allied to *C. macleayi*, the present species differs in the shorter second abdominal segment as well as in details of coloration, etc. Type in S. Australian Museum.

CERIOIDES FACIALIS, n. sp.

♀. Head yellow; ocellary region and vertex stained with brown; front yellow, anterior to ocelli with a broad black transverse band behind and not reaching antennal tubercle, the middle line slightly raised, laevigate, the lateral areas not punctate; face yellow, the median line brownish-yellow, bordered on each side by a dark brown vitta with an outward and somewhat backward extension from middle to orbits, smaller dark patch on each side of antennal tubercle, vertical sides of face with a dark band along upper border; cheeks yellow with brown spot in front, occiput black with a yellow spot above on each side of vertex, antennal tubercle reddish-brown, the apex darker, long, more than twice the length of first antennal segment, the second antennal joint about as long as the first and longer than the third, style dark brown. Mesonotum faintly granulose, black; humeral angles bright yellow, the presutural callus and posterolateral ridge, a small spot to inner side of latter, and a triangular mark in middle of posterior margin also yellow, transverse suture with some short light yellow pubescence. Scutellum yellow, narrowly marked with brown at base and extreme sides. Pleural segments black, a small obscure reddish-brown mark at lower angle of mesopleuron; a bright yellow mark on metapleuron.

Abdomen greatly constricted at base, first segment narrowed from base to apex; second segment longer than first, narrow and subcylindrical at base, thence widened to apex, the remaining segments broad, forming an ovate mass, the third segment longer than the fourth; first segment light reddish-brown with a conspicuous yellow basal border and an indefinite median black mark at apex; second segment yellow on narrow basal portion, thence black with a brownish-yellow apical margin; third and fourth joints black with yellow apical margins; venter mainly black, the basal segment brown with subbasal yellow band, second yellow with blackish apex, the remainder black with narrow yellow apical margins.

Legs reddish-brown, the coxae and basal two-thirds of femora (excepting extreme base), an indistinct submedian band on tibiae and the anterior tarsi (excepting base and apex) darker.

Wings hyaline with dark brown anterior border limited posteriorly by the *vena spuria* as far as base of discal cell, thence by R_{4+5} and including the dip in that vein. Halteres yellow.

Length, 9 mm.

Hab.—N Queensland: Kuranda (Goldfinch, 21-24 Nov., 1925). A single female presented by the discoverer to thé Macleay Museum. The species differs in coloration of face and thorax from all the other species with pedunculate abdomen; the yellow median facial line is quite unusual in Australian species. In the

structure of the basal abdominal segments the species is closest to *C. macleayi*, but the apex of the second segment is wider than in that species, also the antennal tubercle is longer and the porose frontal areas are lacking.

CERIOIDES MASTERSI, n. sp.

♀. Head reddish-brown, a round yellow spot on each side of forehead touching eye margin and opposite the antennal tubercle; vertex with a pair of yellow spots behind the ocelli; face with a yellow longitudinal mark on each side of the reddish-brown median vitta practically joined to a similar yellow spot on eye margin, this spot separated from yellow spot on frons by a broad transverse reddish-brown band; another yellow vitta about halfway down vertical sides of face; median line of frons slightly raised in front of ocelli, no punctate areas on frons; antennal tubercle long, yellowish-brown. Antennae yellowish-brown; first joint about half length of tubercle and shorter than the second, the latter longer than the third; apical style white.

Thorax black, finely granulose, humeral angles, and a patch on lateral margin in front of transverse suture yellowish; transverse suture with some yellowish pubescence; the posterolateral margin brown. Scutellum small, with a few scattered granules, yellow with a central apical patch and the lateral margin reddish-brown. Pleural segments black, a small yellow spot present on mesopleuron, not extending on to other segments.

Abdomen contracted at base; first segment short and narrow, slightly narrower at apex than at base; second segment narrower than first at extreme base, but from basal third rapidly widening to apex; remaining segments wide, the third slightly longer than the fourth; first segment black at base, yellow in middle, with a brown apical margin; second segment yellow on contracted portion, otherwise black; third segment black with a broad apical yellow band; fourth segment with narrow apical yellow margin. Venter dark brown, extreme base black, with a yellow margin and a yellow margin on second segment.

Legs yellowish-brown, the anterior and intermediate femora somewhat darker in middle. Posterior femora not thickened, spinose on under surface in apical half.

Wings pale brown with dark brown apical margin, the dark coloration bounded by the *vena spuria* as far as the r-m cross-vein and extending into the dip of R_{4+5}.

Length, 9 mm.

Hab.—South Australia; a single ♀ (K.52025) in Australian Museum collection.

The coloration of the face might be described better as yellow with median vitta, a broad transverse band in front of antennal tubercle, the upper and lower parts of vertical sides reddish-brown. The coloration of the head and the structure of the basal abdominal segments readily distinguish this species from all others. The brown colour of the wings fills the dip in R_{4+5}, thus distinguishing the species from *C. doddi* and *C. macleayi*.

CERIOIDES SUBARMATA Curran and Bryan.

Cerioides subarmata Curran and Bryan, 1926, p. 133.

I am indebted to Mr. Bryan for a paratype of this interesting species. The peculiar features are the separated eyes of the male, the presence of an obtuse tubercle on the under surface of the posterior trochanters and the incrassate hind

femora. The second abdominal segment is longer than in other Australian species. The wings are brownish, but the colour is intensified along the anterior margin as far back as the *vena spuria*, including the whole of the cell anterior to this fold and the basal portion of cell R_5, the dip in R_{4+5} is also included; Cu_1 is also somewhat suffused.

The species is allied to *C. facialis*, but differs *inter alia* in the facial and thoracic markings, in the shorter antennal pedicle and in the longer second segment. The leg structures are probably sexual, and the ♂ of *facialis* not known.

Hab.—Queensland: Brisbane.

Subfamily ERISTALINAE.

Antennae moderately long, pendent, arista dorsal, bare to plumose. Wings with r-m at or beyond middle of median cell; R_{4+5} with downward loop into first posterior cell (cell R_5); marginal cell (cell R_1) open or closed. Hind femora usually thickened.

The above characterization, which is adapted from Brunetti (1923, p. 154), covers all the known Australian species, with the exception of *Dissoptera pollinosa* Edw. In the latter species r-m is distinctly before the middle of the median cell. While this character would appear to exclude the species from the subfamily, it has been thought advisable, in view of the other venational characters, to follow Edwards and to allow the species to remain in the Eristalinae.

Apart from this species, the Australian members of the subfamily fall into two genera, *Eristalis* and *Helophilus*, though it is possible that the widespread genera *Merodon* and *Mallota* may yet be found to occur. The three Australian genera may be separated as follows:

1. Cell R_1 (marginal cell) open .... *Helophilus*
   Cell R_1 (marginal cell) closed 2
2. r-m at or beyond middle of median cell .... *Eristalis*
   r-m distinctly before middle of median cell .... *Dissoptera*

ERISTALIS.

Eristalis Latreille, 1804, p. 363.

(For synonymy see Brunetti, 1923, p. 155.)

Head as broad as thorax, approximately semicircular; frons only slightly produced, pubescent; face with central knob and moderately produced upper mouth edge; antennae normal, third joint oval with arista dorsal, either quite bare or plumose; eyes usually contiguous in ♂, widely separated in ♀, bare or pubescent, sometimes in part only. Thorax quadrate, densely but often inconspicuously pubescent; scutellum similar clothed. Abdomen about as wide as thorax, ovate or subconical, frequently with markings distinctive of the species, pubescence variable. Legs simple, pubescence variable; hind femora normally not incrassate; hind tibiae usually, but frequently only slightly, curved. Wings with marginal cell closed; R_{4+5} with conspicuous downward loop or dip into first posterior cell which is closed well or just before border by the upward curved tip of M_1; r-m opposite or beyond middle of median cell.

The above diagnosis, which is taken, slightly altered, from Brunetti, covers the Australian species.

The genus is world-wide and various attempts have been made to split it into small genera. The question is ably discussed by Brunetti, who points out that the proposed classification is purely arbitrary, the subgenera embracing

incongruous species. From a study of the Australian forms I am in agreement with this opinion and do not propose to utilize any of the subgeneric divisions. One name, *Lathyrophthalmus* Mik, has been suggested for the group of species with spotted or irregular marked eyes which are contiguous in the male, and several Australian species, e.g. *punctulatus*, would come into it. This subgenus or genus is separated from *Eristalinus* by the contiguous as against separated eyes in the male, so that unless this sex is known the genus remains uncertain. As in other groups the eyes may be separated or contiguous in the male it does not appear that this character is of even subgeneric importance; similarly it does not seem justifiable to separate groups of such closely allied species as are exemplified by *E. muscoides* and *E. resolutus* merely on the character of the plumose or bare arista. There appears even to be some doubt as to the group to which the name *Eristalis* should be applied.

In Australia the genus *Eristalis* is represented, according to our present knowledge, by some 15 species, of which 8 are apparently confined to the continent and Tasmania, 6 are extralimital, occurring also in Papua or the islands to the north of Australia, and one is an introduced species from Europe. These 15 species are inclusive of two described as new in this paper and four extralimital species herein recorded from Australia. In addition six names have been ascribed to Australian species which must be relegated to synonymy. In dealing with introduced or extralimital species it has not been considered necessary to quote the references or synonymy except in so far as Australian records are concerned. In these cases, however, references are given to other papers where fuller accounts may be found.

Distribution: The extralimital species, which include *arvorum*, *collaris*, *kochi*, *resolutus*, *muscoides* and the new species *kershawi*, are limited in Australia to the northern parts of the continent, while the introduced *E. tenax* is practically universally distributed. Of the eight known endemic species four—*roderi*, *smaragdi*, *maculatus*, *conjunctus*—are known only from Queensland and the Northern Territory, two—*copiosus* and *sinuatus*—from Queensland and New South Wales, and two—*punctulatus* and *pulchellus*—have an extended range from Queensland to Western Australia, including Tasmania.

It is probable that the number of known species will be greatly extended when the fauna of the northern and western portions of Australia is better known.

Life History.—Little or nothing is known of the life history of Australian species, with the exception of the introduced *E. tenax* L.; the larvae of *E. smaragdi* and *E. punctulatus* have, however, been found by Dr. Mackerras in drainage from a hospital at Eidsvold, Queensland, and successfully reared. The larvae had the long siphon characteristic of the species—hence the name rat-tailed larvae. Both species have also been bred by Mr. A. P. Dodd from rotten prickly pear (*Opuntia* sp.).

In the table of species given below the species have been largely grouped by the characters given by de Meijere in his key to the Oriental species of the genus, as these appear to divide the Australian species into fairly natural groups. *E. tenax* stands by itself and is obviously of different type from the native Australian groups, while *E. pulchellus* is also a species with no very close relatives. The main number of the species falls either into the group with black thoracic stripes on a more or less yellow ground or into the group with metallic coloration. A single representative of the species with transverse bands on the thorax—*E. collaris*—is here recorded.

Table of Species of Eristalis.

1.	Nonmetallic species	2
	Species with metallic coloration	8
2.	Mesonotum uniformly clothed, without distinct pattern, eyes with two bands of pubescence	*E. tenax* L.
	Mesonotum not uniformly clothed, pattern of either stripes or bands present, pubescence of eyes not in two bands or eyes bare	3
3.	Mesonotum with black stripes	4
	Mesonotum with transverse bands	*E. collaris* de Meij.
4.	Admedian thoracic stripes fused, thorax trivittate	*E. conjunctus*, n. sp.
	Admedian stripes separate, thorax quadrivittate	5
5.	Longitudinal stripes little distinct, facial hump prominent	*E. kochi* de Meij.
	Longitudinal stripes strongly differentiated against a yellow or grey background; facial hump less prominent	6
6.	Abdominal pattern with grey bands and spots	*E. maculatus* de Meij.
	Abdominal pattern with yellow bands and spots	7
7.	Eyes in male with upper facets much larger than lower; thoracic stripes with brown tomentum; upper margin of light band on second segment (♀) not interrupted on each side	*E. arvorum* F.
	Eyes in male with smaller upper facets, though still somewhat larger than lower facets, thoracic stripes laevigate; upper margin of light band on second segment (♀) interrupted on each side by a dark mark	*E. punctulatus* Macq.
8.	Mesonotum green with a pair of prominent dark spots, eyes separated in ♂	*E. pulchellus* Macq.
	Mesonotum metallic coloured with more or less distinct darker stripes; eyes contiguous in ♂	9
9.	Arista plumose	10
	Arista bare	11
10.	Pubescence dark; third abdominal segment trivittate	*E. muscoides* Walk.
	Pubescence light; third abdominal segment trimaculate	*E. roderi* Berg.
11.	Wings shaded brown	12
	Wings clear, glassy	13
12.	Large dark blue species (17 mm.) with indistinct thoracic markings	*E. kershawi*, n. sp.
	Medium-sized species (12 mm.) with distinct thoracic pattern	*E. resolutus* Walk.
13.	Small green species with markings obsolete, venter dark	*E. smaragdi* Walk.
	Medium-sized species with yellow venter	14
14.	Abdomen metallic green with yellow side-spots on second and third segments (♂), or on second segment (♀)	*E. sinuatus* Thoms.
	Abdomen with central tawny stripe	*E. copiosus* Walk.

Eristalis tenax L.

Musca tenax Linnaeus, 1758, p. 591.—*Eristalis tenax* de Meijere, 1908, p. 244; Hardy, 1921, p. 16. (For synonymy see Brunetti, 1923, p. 173).

Widely distributed throughout Australia, this well known introduced species requires no description. It cannot well be confused with any indigenous species, though the species herein recorded as *E. kochi* de Meijere has a certain superficial resemblance; the bare eyes in the latter species will at once separate it.

Eristalis collaris de Meij.

E. collaris, de Meijere, 1907, p. 258.

A single male from Claudie River, N. Queensland, in the National Museum, Melbourne, agrees well with de Meijere's description, except that the light transverse thoracic band is broadly, though somewhat indistinctly, interrupted in the middle line.

Two females from Lizard Is. in the Macleay Museum also appear to belong here; one agrees well with the description; in the other the central facial vitta is more black than "rotgelber"; a third female in the Health Department collection from Port Moresby, New Guinea, has the facial vitta decidedly black with a faint

steely tinge. The species would thus appear to be somewhat variable and the specimens are too close to *E. collaris* in other characters to admit of separation in my present state of knowledge.

Hab.—New Guinea (de Meijere); Queensland: Claudie R., Lizard Island.

ERISTALIS CONJUNCTUS, n. sp.

A short, rather convex, species, yellow, with three dark longitudinal stripes on mesonotum.

Head transverse, about as wide as mesonotum. Eyes closely contiguous for a considerable distance; vertex dark brown with light brown hairs, ocelli prominent, yellow; frontal triangle somewhat produced, reddish-brown with greyish pubescence, the short narrow parafrontals with greyish-yellow tomentum; face with tubercle obtuse, not markedly prominent, median vitta brown, laevigate, light yellow-brown in centre, darker on each side; sides with dense greyish-yellow tomentum, lower border broadly laevigate, yellow-brown; cheeks brownish-yellow with grey pubescence; posterior margins with yellow tomentum below, becoming darker above; antennae brown, third joint with darker upper margin, and longer than wide, arista bare; eyes bare, with larger facets above, the transition between the two kinds of facets abrupt and the difference in size considerable. Mesonotum densely clothed with bright yellow tomentum, with three longitudinal black vittae, the median vitta broader and apparently composed of two closely approximated stripes, an indication of a narrow median grey line being present; in the posterior third this vitta becomes yellow-brown, extending as such to scutellum, lateral vittae hardly interrupted by the transverse suture which is clothed with yellow-brown tomentum, the portion of the vitta posterior to the suture narrowed behind and ending in a long point; a small transverse mark in transverse suture external to lateral vitta black; humeri and supra-alar region yellow-brown, posterolateral ridge dark brown. Scutellum yellow, darker and more brownish at base, pubescence short, dark yellow along free margin. Sides yellow-brown above, dark brown below, with an oblique grey tomentose band from mesopleuron to posterior portion of sternopleuron. Abdomen golden yellow, the first with darker median mark at base, the second with apex darker yellow-brown, this colour extending forward slightly in mid-line, a pair of lighter yellow tomentose spots on each side of mid-line; third and fourth segments with three darker yellow-brown vittae extending full length of these segments, the space between the median and sublateral vittae on each side with bright gold tomentum. Venter yellow. Legs brownish-yellow, the tarsi darker. Wings clear. Venter normal; calypters yellow with golden fringe. Halteres yellow.

Length, 7 mm.

Hab.—Queensland. A single ♂ in the Macleay Museum collection.

In a second male from South Palm Island, the colours generally are darker, the median vitta is practically black throughout, the scutellum is darker brown and the pleural segments practically black, except on pteropleuron and those portions of meso- and sternopleura which are grey tomentose; the transverse banding of second segment and the three longitudinal vittae on third and fourth segments are much darker and very conspicuous.

In the single female before me (Claudie R., Queensland, J. A. Kershaw 11-12. 2. 1913) the colours are as in the Palm Island male; the front is black, clothed with dense golden-brown tomentum with a band of black tomentum in front of ocelli; the antennal prominence is black with greenish reflections and the lunula brown.

Since the above was written I have seen another female in the Queensland Museum from Cairns (A. P. Dodd); this has the colours as in the Palm Island male and the abdominal vittae are well marked. It is probable that the type may be somewhat faded.

ERISTALIS KOCHI de Meijere.

Eristalis kochi de Meijere, 1908, p. 255.

A male in the collection of the New South Wales Department of Health from the Northern Territory and one in the Queensland Museum from Brisbane agree well with de Meijere's description of *E. kochi* and, until evidence to the contrary is forthcoming, should, I think, be referred to de Meijere's species.

At first sight the species resembles *E. tenax*, but the eyes are bare and the thorax is vittate, though the vittae are not so sharply marked off from the ground colour as in other vittate species.

Hab.—New Guinea (de Meijere); Australia, Northern Territory: Katherine River (H. W. Brown); Queensland: Brisbane (H. Hacker, 12.2.18).

ERISTALIS ARVORUM F.

E. arvorum Fabricius, 1787, p. 335.

(For synonymy see Brunetti, 1923, p. 181.)

This species is recorded from Australia by Curran and Bryan (1926, p. 129), the record being based on a specimen from Babinda, North Queensland. There are before me a series of specimens from N. Queensland which are certainly distinct from *E. punctulatus* and which may be *E. arvorum*. I am, however, not satisfied of the identity of the specimens.

In all the specimens the legs are quite pale, a feature characteristic of *E. arvorum*, but the abdominal markings, particularly in the female, differ very much from the figures of this species given by Brunetti (1923, Pl. iv, fig. 6, 7). The description given by this author (pp. 181-3), however, is much more in agreement with the markings found on the Australian specimens. It would appear both from Brunetti's and from de Meijere's descriptions that the abdominal pattern is but little different in the two sexes, though according to Brunetti it may vary considerably in both sexes. This variation would practically cover the markings of both sexes of the Australian form, but in the Australian specimen the pattern is fixed and different in each sex. *E. arvorum* is an Oriental species whose range is from China to India and Java; I have seen no record from Papua, and one would expect intermediate records.

It is to be noted that de Meijere (1908, p. 265) expressed the opinion that *E. punctulatus* was closely allied to *E. suavissimus* Walker, and the Australian specimens agree well with de Meijere's description and figure (1908, Pl. 8, fig. 26), except in so far as the femora are darker in *suavissimus*. Until authentic specimens of *arvorum* are available for comparison, the question of the identity of the Australian specimen must remain open.

E. fulvipes Macq. (1846, p. 128) is placed by Brunetti as a synonym of *arvorum*, following Austen who examined the presumable type in the Verrall collection. This identification is in favour of the North Queensland specimens being *E. arvorum*, since *E. fulvipes* was described from Australia. But for Austen's identification I should have been tempted to regard *E. fulvipes* as founded on a discoloured specimen of *E. punctulatus*.

The Queensland specimens are from the following localities: Claudie River (4 ♂), Kuranda (♀), Great Palm Island (♀). It will be noted that the males

and females are from different localities, which renders less certain their specific identity. They, however, differ from each other as do the sexes of *E. punctulatus*.

ERISTALIS PUNCTULATUS Macq.

Eristalis punctulatus Macquart, 1846, p. 59; 1850, p. 137; de Meijere, 1908, p. 265, Pl 8, fig. 26; Hardy, 1921, p. 16.—*E. agno*, Walker, 1849, p. 626; Klocker, 1924, p. 57.—*E. epitome*, Walker, 1852, p. 250,

Hardy (1921) has recorded the above synonymy; Klocker regards *agno* Walk. as distinct, but a specimen in the Queensland Museum identified by Klocker as *E. agno* is stated by Hardy (*in litt.*) to be merely the male of *E. punctulatus*. There is nothing in the original description of *E. agno* to differentiate it from *E. punctulatus*. I have, however, not had an opportunity of comparing Western Australian specimens with specimens from the eastern side of the continent.

E. punctulatus is readily distinguished from the species identified as *E. arvorum* by the upper facets of the eyes of male being only slightly larger than the lower facets and much smaller than the corresponding facets in that species. In the female the pattern of the second abdominal segment is distinctive, the broad light bands are well separated in the middle line and reach the anterior margin at each end of the band, but show a dip away from the border in the middle of the band.

This species has been bred from rat-tailed larvae found in drainage from the local hospital at Eidsvold, Queensland (Dr. I. M. Mackerras). Mr. A. P. Dodd informs me that he has bred it also from rotting prickly pear (*Opuntia* sp.).

ERISTALIS MACULATUS de Meijere.

Eristalis maculatus de Meijere, 1908, p. 266, Pl. 8, fig. 25.—*Eristalis herve-bazini* Klocker, 1924, p. 58, Pl. 10, fig. 3.

Specimens from Brisbane and elsewhere in Queensland and the Northern Territory agree closely with the description and figure of *E. herve-bazini* Klocker. They also agree fairly well with the description of *E. maculatus* de Meijere except that the outer ends of the white bands on the second abdominal segment are not so sharply demarcated as shown in de Meijere's figure, but merge into the light areas on the sides of the segment. De Meijere hints that *maculatus*, as well as *punctulatus*, may be merely a race of *E. suavissimus*.

Hardy is of opinion (private communication) that *herve-bazini* was founded on a greasy specimen of *E. punctulatus*, but the specimen in the Queensland Museum examined by Hardy is not the type and is not identical with the specimens in the Departmental collection which do agree with Klocker's description and figure. It is to be noted that the types of the new species of Syrphidae described by Klocker were not returned to the Queensland Museum.

I regard the synonymy given above as probably correct and the species as a good one, readily separated from *punctulatus* in colour and pattern.

ERISTALIS PULCHELLUS Macq.

Eristalis pulchellus Macquart, 1846, p. 127; Hardy, 1921, p. 16.—*Eristalis aebutius* Walker, 1849, p. 630.

A very distinct and easily recognized species, not closely related to other Australian forms, and with a wide range over the southern part of the continent. The above synonymy has already been recorded by Hardy (1921, p. 16).

Macquart's description is much more accurate than Walker's description of *E. aebutius*, and it might even be questioned if the species were not distinct, but

for the fact that there is a typical specimen of *E. pulchellus* in the National Museum, Melbourne, which was identified by Miss Ricardo as *E. aebutius*.

As the ♂ does not appear to have been described a description is here given.

♂. Head clothed as in ♀, eyes separated by a little more than one-third the width of an eye, bare, finely faceted; forehead bluish-black posteriorly with dense black pubescence, parallel-sided, yellow anteriorly with yellow pubescence and produced forwards, the sides diverging; face perpendicular for short distance below antennae, thence produced forwards into the prominent facial hump, beneath the latter the face retreating to oral margin which is somewhat produced above, pubescence yellow; cheeks rather broad, white tomentose, with grey hairs; occipital margin with white tomentum; antennae bright reddish-yellow, third joint ovate, arista bare, brown. Mesonotum brassy-green with faint indications of darker admedian lines in anterior portion and with a prominent black, tomentose, spot on each side at inner end of suture, pubescence yellow. Scutellum deep violet, with purple reflections. Pleural segments brassy-green with long golden pubescence. Abdomen in middle bright bluish-green, first segment bluish-black, second segment with a dark bluish apical margin produced in mid-line, leaving a small greenish spot at extreme apex, third segment with a subbasal and median spot and a larger apicolateral spot dark bluish-black; fourth segment with three similar but smaller and more rounded spots, the median one reaching the basal border. Legs yellowish, the basal half of anterior and middle femora and the basal two-thirds of hind femora brassy-green, the apical third of hind femora deep violet, anterior tibiae slightly infuscated in apical third, the hind tibiae more conspicuously so, tarsi black. Wings clear, venation normal. In the female the eyes are farther apart and the sides of the front strongly divergent.

Length, 11 mm.

Hab.—Queensland to Western Australia and Tasmania. The species is rare in New South Wales and the only Queensland specimens I have seen are those in the Macleay Museum noted by Hardy. It appears to be common in Victoria, South Australia and Western Australia.

ERISTALIS MUSCOIDES Walker.

Eristalis muscoides Walker, 1859, p. 96; de Meijere, 1908, pp. 270-6.

Two specimens are before me from Koolpinyah, N. Territory (G. F. Hill) labelled *E. muscoides* Walk., id. at British Museum. While undoubtedly closely allied, I believe the two specimens to represent two species, the male agreeing well with de Meijere's notes on Walker's species and the female with Bergroth's description of *E. roderi*. I was inclined at first to consider the differences sexual, but Mr. Hill has sent me both sexes of *E. roderi* from Townsville and the same differences are apparent between the males of the two species as between the Koolpinyah male and female. While the difference in part hinges on the abdominal pattern and de Meijere notes that this may vary in *E. muscoides*, the variation being in the direction of shortening of the sublateral vittae on the third abdominal segment, the other differences are too marked to allow me to consider the species as other than distinct.

Hab.—Aru, Ambou; New Guinea; Australia, N. Territory: Koolpinyah (G. F. Hill).

Var.—Three specimens (♂) from North Queensland differ from the Northern Territory male in their deep blue coloration with purple and violet reflections. In two males from Gordonvale the scutellum is reddish with purple reflections, while in a male from Meringa the scutellum is deep blue. There does not seem

to be any structural difference between these three specimens and the Northern Territory specimen identified as *E. muscoides*, and the pattern is identical. Further specimens may yet prove this form to be a distinct species, but it would be unwise in the present state of our knowledge to separate it. The three specimens approach the description of *E. cupreus* de Meij., but the hairs are certainly not "fahlgelb", an indication that they do not belong to de Meijere's species.

ERISTALIS RODERI Bergroth.

Eristalis roderi, Bergroth, 1894, p. 72.

Though closely allied to *E. muscoides*, this species may be distinguished by its generally lighter pale blue coloration and by the frontal triangle in the ♂ densely yellowish-white tomentose and pubescent, and not metallic green with black hairs; by the narrower median thoracic vitta broadening behind suture, the rest of the broad vitta of *E. muscoides* being very indistinctly indicated; by the vittae of the third and fourth abdominal segments being represented by short spots, the median near anterior, the sublateral at posterior margin; and by the general pale yellowish pubescence.

Hab.—Queensland: Coomooboolaroo (Bergroth), Townsville (G. F. Hill); N. Territory: Koolpinyah (G. F. Hill).

ERISTALIS KERSHAWI, n. sp.

A large metallic-blue species with dark wings.

♂. Head large, hemispherical. Eyes contiguous for a considerable distance, ocellary triangle raised, metallic-blue, the ocelli reddish-brown, hairs on vertex black; frontal triangle rather strongly produced, metallic-blue with violet reflections, with black hairs more conspicuous in upper part; parafrontals narrowly grey tomentose, the grey fading away above; face concave beneath antennae, produced to an obtuse tubercle, thence falling vertically to oral margin, middle broadly blue with violet reflections, the sides grey tomentose, lower border black; cheeks narrow, black, grey tomentose, posterior margin grey tomentose with rather long grey pubescence; eyes bare, with somewhat larger facets above, no sharp line of demarcation between the larger and smaller facets. Antennae dark brown, the third joint black, rather short; arista long, dark brown, bare. Mesonotum dark metallic-blue with indistinct markings; a patch of grey tomentum at inner side of base of humeral angle and a second patch internal to this, the transverse suture also grey tomentose; seen from side a pair of dark grey tomentose stripes are present in mid-line from anterior margin to middle, separated by a darker almost black line; an indistinct elongate triangular black mark behind transverse suture; pubescence black. Scutellum deep blue with violet iridescence, pubescence short, black. Pleural segments dark blue, somewhat dull and becoming brownish anteriorly and on hypopleuron, the latter grey tomentose; pubescence pale on sternopleuron and upper part of mesopleuron, elsewhere dark. Abdomen dark blue with greenish reflections, the third segment with a broad patch of reddish-yellow at sides extending as a narrow band along apical border; fourth segment mainly reddish-brown with a broad ill-defined purple iridescent patch at base; genital segments dark brown. Venter black with green and purple iridescence, the membranous connections between tergites and sternites and between the sternites bright golden-yellow.

Legs dark, with purple and violet iridescence, the anterior and intermediate tibiae reddish-brown, tarsi also dark reddish-brown; anterior femora with grey

pubescence along posterior surface, intermediate femora with moderately long grey pubescence at base, the pubescence elsewhere dark.

Wings dark brown, somewhat lighter along posterior edge, venation normal. Calypters black with yellow fringe along margin of lower calypter; halteres yellow.

Length, 17 mm.

Hab.—Queensland: Claudie R. (J. A. Kershaw, 11-12. 2. 1913).

This handsome species is quite unlike any known Australian form and is probably of Papuan origin. I cannot find, however, that it has been described from New Guinea or the East Indian Islands. Two males and a female in the Australian Museum from the Fly and Oriomo Rivers, Papua, appear to belong here, the only difference being the somewhat larger size (22 mm.).

In de Meijere's key to the Oriental species, the present one would apparently fall into the same division as *E. resolutus* and *E. fenestratus*, though the thoracic pattern is almost obsolete. From these two species it differs in its much larger size and in coloration.

Eristalis resolutus Walker.

Eristalis resolutus, Walker, 1859, pp. 95, 129.

A pair from Kuranda agree closely with de Meijere's notes on this species and also with Walker's original description. The species belongs to the *E. smaragdi* group, but differs from *E. smaragdi* in its larger size and purplish, not green, colour; the arista is bare.

Hab.—Aru Islands; Key Islands; Sula; New Guinea; Australia, N. Queensland: Kuranda (Dodd).

Eristalis smaragdi Walker.

Eristalis smaragdi Walker, 1849, p. 361.

A small metallic-green species with golden and coppery reflections; the thoracic markings seen in other metallic species are obsolete, there being only faint evidence of tomentose admedian stripes before the suture. The abdomen is likewise almost concolorous, but faint indications of darker markings are seen along the anterior and posterior margins of second segment, as a median vitta on same segment and in male as three vittae on third segment, in female as a single vitta. The arista is bare.

The male has not been described and hardly differs from the female except in the contiguous eyes, the upper facets of which are not appreciably larger than the lower, and in the slightly more evident abdominal pattern.

Dr. I. Mackerras has bred the species from rat-tailed larvae found in sewage from the hospital at Eidsvold, Queensland. Mr. A. P. Dodd has also bred this species from rotting prickly pear (*Opuntia* sp.). *E. smaragdi* has a wide range in tropical Australia; specimens are before me from Darwin, Northern Territory, Kuranda and Eidsvold, Queensland.

Eristalis sinuatus Thoms.

Eristalis decorus Macquart, 1848, p. 41, Pl. 4, fig. 4; Schiner, 1868, p. 362; Hardy, 1921, p. 16 (nom. praeocc.).—*Eristalis sinuatus* Thomson, 1868, p. 488.

A metallic blue-green species with bright yellow head, legs and venter. The thoracic markings are similar to those present in *E. muscoides* and *E. resolutus*, but are somewhat obscure. In the female the yellow markings are confined to the second abdominal segment, while in the male the yellow is more extensive and

is present on the sides of the third segment. Eyes bare, holoptic in male, the upper facets hardly larger than the lower. Antennae with bare arista.

The above synonymy is recorded by Hardy and appears to be undoubtedly correct. Hardy, however, overlooked the fact that the name *decorus* had been used by Perty* prior to Macquart.

The species is widely distributed along the Eastern Coast. Specimens before me were taken at Dinner Creek, Ravenshoe, N. Queensland, while the species is common at Sydney. Specimens may frequently be taken on flowers, particularly those of *Angophora cordifolia*. Nothing appears to be known of the life history.

ERISTALIS COPIOSUS Walker.

Eristalis copiosus Walker, 1852, p. 249; Klocker, 1924, p. 57.

Described from an unknown locality, Klocker has recorded this species from Brisbane.

The species is unknown to me, and it is not represented in any Sydney collection, though readily recognizable from the yellow median abdominal stripe. The remainder of the description suggests that the species is probably allied to *E. sinuatus* Thoms.

It is possible that the species is actually founded on the male of *E. sinuatus* Thoms. The original description of the abdomen is as follows: "Abdomen . . . . with a broad tawny stripe from the base till near the tip which is blue, and has near it an almost annular brassy green mark; underside tawny".

In *E. sinuatus* Thoms. there is a tawny vitta *on each side*, the median line being dark. Unless, therefore, there is an error in the original description the species must be distinct.

HELOPHILUS.

Helophilus Meigen, 1922, p. 368.—*Orthoprosopa* Macq., 1850, p. 143.

(For other synonymy and references see Brunetti, 1923, pp. 204-5.)

Resembles *Eristalis*, but differs in the marginal cell (cell R_5) being open. Eyes always bare, separated or contiguous for only a short distance in ♂, always widely separated in ♀; arista always bare; posterior femora thickened, posterior tibiae curved.

The open marginal cell mainly distinguishes this genus from *Eristalis*. Brunetti states that the eyes in the male are always narrowly but distinctly separated, but admits species in which the eyes are contiguous, though only for a short distance.

Hardy (1921, p. 15) apparently relies on the contiguous eyes for separating *Orthoprosopa* from *Helophilus*, but the eyes are no different in the genotype of *Orthoprosopa* from those of such species as *Helophilus hilaris* and *H. bengalensis*.

In the New Zealand species, such as *H. trilineatus* F., the eyes are widely separated in the male and the facial structure is different from that in *Orthoprosopa*. In *O. grisea* the face descends at first with a slight concavity, thence straight from the base of antennae to the oral margin; this is also the case in *H. hilaris* and *H. bengalensis*, except that the lower portion of the front is subcarinate. In the New Zealand species and also in the new species described herein as *H. terrae-reginae* the concavity is more pronounced and below it the face is produced into a prominent knob or hump. *H. terrae-reginae*, however, differs from the New Zealand species in the eyes being contiguous for a short

* Kertesz Catalogue gives the reference as follows: "*decora* Perty. Delect. animal artic. Brasil, 185 Tab. xxxvii, fig. 3 (1830-34)".

distance in the male. In an undescribed species from South Australia, a single damaged male of which is before me, a conspicuous facial bump is present and the eyes are barely touching at one point. Brunetti, in his description of the Indian species, does not mention the facial hump, except in the case of *H. bengalensis*, when he says "central bump small".

De Meijere in most cases makes no mention of a central hump, and in the description of *H. scutatus* he says: "Unter gesicht . . . . ohne Andeutung eines Hockers". Only in the case of *H. fulvus*—which in coloration is very close to my *terrae-reginae*—does he describe the hump as present—"der Hocker also stark vortretend, gross, gerundet, glanzend schwarz".

It would thus appear possible to divide at least the Australian species into two groups, on the facial structure, but I doubt if the division can be considered sufficiently distinct to warrant their separation into genera or even subgenera.

Distribution.—One species, *H. bengalensis*, is extralimital, the range including the northern portion of Australia as far south as the Richmond River in New South Wales. Two others, *H. hilaris* Walk. and *H. terrae-reginae*, n. sp., are only known from Queensland. *H. ruficauda* Bigot is merely described from Australia. The remaining described species, *H. griseus* Walk., is apparently restricted to New South Wales, Macquart's record from Tasmania being in all probability erroneous*. As noted above an undescribed species occurs in South Australia.

Life History.—But little is known of the life history of the Australian species of *Helophilus*. Brunetti says of the genus (1923, p. 205) that the larva lives in stagnant water and is not readily distinguishable from that of *Eristalis*. In *H. griseus* Walk. the larvae live in the fluid slime found between the outer shell and the core in rotting grass-tree (*Xanthorrhoea*) stumps and have been described by Skuse and by Froggatt. They are noteworthy in possessing very short, straight anal tubes.

Table of Species of Helophilus.

1. Face with pronounced median hump. (General coloration bright orange-yellow with narrow incomplete thoracic vittae) .... *H. terrae-reginae*, n. sp.
   Face without pronounced median hump 2
2. General coloration black, with yellow face .... *H. griseus* Walk.
   General coloration yellow and black, mesonotum with three conspicuous black vittae 3
3. Intermediate femora in ♂ with basal tooth and subapical emargination and tooth; third segment in ♀ mainly orange with black posterior margin .... *H. bengalensis* Wied.
   Intermediate femora with only basal tooth, apex not emarginate nor toothed; third segment in ♀ mainly dark with yellow lateral marks .... *H. hilaris* Walk.

Note.—*H. ruficauda* Bigot is omitted from this table, as the description is insufficient to enable me to place it in the tabulation.

Helophilus terrae-reginae, n. sp.

A large fulvous yellow species with four incomplete black dorsal vittae on thorax and an interrupted median vitta on abdomen.

♂. Eyes briefly contiguous, ocellary triangle dark brown with a little yellow tomentum; frontal triangle densely clothed with pale yellow tomentum, the apex of the antennal tubercle bare, dark brown and shining; face clothed with similar tomentum, the median line bare, black, the central knob prominent, black and shining, the lower portion of the sides of snout also black and shining; cheeks

* I have since seen Western Australian specimens.

narrow, clothed with pale yellow tomentum, as is also occipital region; pubescence on head bright yellow, with a few dark hairs about ocelli; antennae bright reddish-yellow, arista bare. Mesonotum densely clothed with golden-yellow tomentum, with two median black lines slightly nearer each other anteriorly and extending from apical margin to halfway between suture and scutellum, the intervening space wider than either line; also with an interrupted sublateral vitta on each side, the portion in front of the suture subovate, the portion behind narrowed and drawn out into a long point, pubescence of a deep golden colour thicker and deeper in colour at sides. Scutellum entirely deep golden, not covered with tomentum but clothed with long deep golden pubescence. Pleural segments clothed with yellow or yellowish-grey tomentum, pubescence bright golden. Abdomen densely clothed with bright golden tomentum and with golden pubescence, the base of second segment with a transverse black band, not reaching the sides and extended in mid-line to form a longitudinal vitta broken in apical third of segment, but continued on third segment for little over half the length of the segment and barely indicated as a narrow line on basal half of fourth segment; genital segments half rotated. Venter in basal portion black with pale segmentations, the apical portion reddish-brown to golden at apex. Coxae, trochanters and femora black, the extreme apex of the latter yellow, tibiae and tarsi bright reddish-yellow; pubescence golden except on under surface at apex of posterior femora; posterior femora greatly thickened, deep from above downwards, the dorsal surface strongly declivous near apex, ventral surface gradually expanded towards base on posterior border, the surface flattened; posterior tibiae bowed, the ventral surface bisinuate with a blunt tooth situated slightly to the base of the middle of the tibiae. Wings clear, slightly suffused with brown along cross-veins; venation as in genus. Calypters yellow with yellow fringe. Halteres yellow.

Length, ♂. 14 mm.

Hab.—Cairns District (F. P. Dodd). Type in South Australian Museum.

Described from a single ♂; the species must be remarkably close to *H. fulvus* de Meij. described from New Guinea, in the thoracic and abdominal ornamentation, but the legs are described in that species as quite black, and there is no mention of the great thickening of the posterior femora, from which I infer that the legs are simple in *H. fulvus*.

In the pronounced facial knob the species differs from other described Australian species and approaches the forms found in New Zeland; the eyes are, however, contiguous for about one-sixth of the distance from vertex to frons, not widely separated.

HELOPHILUS GRISEUS Walker.

Helophilus griseus Walker, 1835, p. 472; Froggatt, 1907, p. 303; Klocker, 1924, p. 59.—*Meredon contrarius* Walker, 1849, p. 599.—*Orthoprosopa nigra* Macquart, 1849, p. 153, Pl. xiii, fig. 5; Skuse, 1888, p. 423 (larvae); Froggatt, 1896, p. 83, Pl. ix, fig. 6-8.—*O. binotata* Thomson, 1869, p. 492.—*O. grisea* Hardy, 1921, p. 16.

A medium-sized black species with reddish-yellow face clothed with bright golden tomentum, reddish-yellow antennae, a pair of black tomentose spots on the mesonotum at inner end of suture, white tomentose spots at base of second, third and fourth abdominal segments, black legs and tarsi with golden pulvilli and bases of claws, and smoky-grey wings. Eyes bare, contiguous in male for about one-seventh of distance from vertex to apex of front, facets equal. Arista bare. The face is gently and evenly concave from below antennae to oral margin which

is slightly produced. Posterior femora thickened, the outer edge rather feebly produced subapically, but without definite tubercle or tooth. Venation typical of genus.

Hardy, under the name *Orthoprosopa grisea*, has recorded most of the above synonymy. I have included also *Orthoprosopa binotata* Thoms. which does not appear to differ in any detail from *H. griseus* Walker and the type was from Sydney where this species is common.

Apart from the colour there seems no reason to separate this species generically from *H. hilaris* and *H. bengalensis*, unless it be on larval characters.

The larvae and pupae have been described by Skuse (1888, p. 23) and Froggatt (1896, p. 83). The larvae are of Eristaline type, except that the siphon is a short tube and not extremely long. This may be associated with the special habitat of the larvae which are found in rotting grass-tree stumps (*Xanthorrhoea*) between the caudex and outer shell.

HELOPHILUS BENGALENSIS Wied.

Helophilus bengalensis Wiedemann, 1819, p. 3.

(For references and synonymy see Brunetti, 1923, p. 209.)

Froggatt (*Australian Insects*, p. 303) records *H. bengalensis* Wied. from Queensland. Hardy (1921, p. 16) does not include the species, but mentions that specimens of *Eristalis punctulatus* were found in various collections under the name of *Helophilus bengalensis* Wied.

While I have not seen the specimens upon which Froggatt based his records, the species certainly occurs in Australia, as there is a series of both sexes in the Macleay Museum from Queensland. These specimens agree with the descriptions and figures given by de Meijere (1908, p. 233, Pl. 7, fig. 13, 14) and Brunetti (1923, p. 209, Pl. v, fig. 1-3). The structure of the intermediate femora in the male is characteristic; there is a small tooth at base and at apex the shaft is suddenly contracted or excavate with a small tooth projecting over the cavity; this character readily distinguishes the male from the male of *H. hilaris* Walker which is very similar in colour. Eyes contiguous in male for about one-third distance from vertex to frons, bare, the upper facets larger than the lower. The general colour is yellow with three prominent black stripes on mesonotum. As the females of this and the following species are hardly distinguishable except on details of the abdominal banding, the following description is taken from Brunetti: "Abdomen: first segment black, remainder orange yellow; second segment with basal and hind marginal black bands, broader in middle (former not attaining, latter attaining, side margins), joined by a median black band of varying width which may sometimes be practically absent; hind marginal band sometimes replaced by merely a deeper orange than the ground colour; third segment with a depressed black triangular spot on hind margin, reaching side margins and often extended forward in centre as a fine line as far as middle of segment. Pubescence on first three segments very short and fine, yellow on yellow parts, dark brown on black parts, fourth segment with close yellow, yellowish-grey or orange tomentum; hind margin more or less moderately shining brown or blackish; a bow-shaped or inverted V-shaped mark, which may be deep orange, brown or black lies (the convexity forwards) across middle of segment; space between it and the hind margin (which latter is not always definite) darker than on anterior half of segment".

In the male in Australian specimens the coloration of the dark parts is in general lighter than on the female, and the markings on the third and fourth

segments may be but little darker than the general surface; the pattern is, however, the same.

Hab.—Extralimital; Australia, Queensland: Port Curtis (2 ♂), Rockhampton (1 ♀). Also a male and a female each with a printed label "Sydney". This locality requires confirmation, as the specimens are old and faded and it is probable that the labels were attached at a later date. The Port Curtis and Rockhampton specimens are labelled in the late Mr. Masters's handwriting and were probably captured by that collector.

HELOPHILUS HILARIS Walker.

Helophilus hilaris Walker, 1849, p. 605; Klocker, 1924, p. 59.

A species closely allied to *H. bengalensis*, distinguishable by the structure of the intermediate femora in the male, and in the female by the abdominal coloration.

The intermediate femora show a small tooth at base as in *H. bengalensis* though smaller, but the apex is not suddenly cut away as in that species, but gradually slopes to the joint and there is no subapical tooth. The abdominal pattern is very similar to that of *H. bengalensis*, but the third segment is almost entirely dark brown with a varying amount of yellow at the sides and sometimes on the anterior margin. The black apical margin of *H. bengalensis* is represented in one female by a dark grey tomentose band, the grey dusting more distinct where it adjoins the basal dark portion; in one male the apical band is dark brown like the rest of the segment, but separated by an incomplete narrow grey band. In two other specimens the abdomen is somewhat greasy and the colour obscured, but the third segment is distinctly dark. In one male (Richmond R.) the sides of the second segment are also dark. Four specimens are under examination, of which two (♂ ♀) from Darwin are labelled as identified at the British Museum for G. F. Hill.

Hab.—N. Territory: Darwin (26.8.15, ♀; no date, ♂, G. F. Hill), Katherine River (H. W. Brown); Queensland: Brisbane (Klocker); N.S. Wales: Richmond River (Oct., 1922, ♂, Thorn).

HELOPHILUS RUFICAUDA (Bigot).

Mesembrius ruficauda, Bigot, 1883, p. 344.

This species is unknown to me; it is described as having a black thorax with two longitudinal grey bands and yellowish sides; the abdomen black with, on each side of second and fourth segments, a large yellowish-white (d'un blanc un peu jaunâtre) macule and on third segment a similar pair of pale fulvous (d'un fauve pale), the posterior border of the third segment obscure fulvous, shining, the fourth widely bordered with the same, fifth black. No mention is made as to whether the eyes are separated in the male, but this is presumably the case since the front in the type (a male) is described as "front jaune, d'un noir luisant aux dessus de la base des antennes, vertex d'un noir opaque." No mention is made of the presence of a central facial knob, the face being described as "facie flava, flavo villosa et nigro-vittata."

From the general description it would appear that the species is allied to *H. hilaris* or to *H. bengalensis*, if indeed the species is not identical with one or other of these.

Hab.—Australia.

DISSOPTERA.

Dissoptera Edwards, 1915, p. 410.

Head as broad as thorax, subhemispherical; vertex broad, extending for some distance behind eyes; ocelli small, situated relatively far forward; eyes separate in both sexes, in male forehead at narrowest one-fifth of total width of head, in female slightly wider, front long, sloping downwards anteriorly to lunule, not prominently produced; face rather narrow, almost perpendicular, without hump or tubercle, slightly produced to oral margin, the latter feebly dentate at apex, lower margin of mouth parallel with general plane of body, not produced downwards; mouth opening long; proboscis rather short; cheeks narrow, small; posterior orbits broad, clothed with a collar of dense upright pubescence. Antennae situated at middle of head height, small, pendent, first and second joints short, third suborbicular, arista dorsal, subbasal, long. Eyes equally faceted, bare. Mesonotum slightly longer than wide, subparallel-sided. Scutellum comparatively large, apical margin rounded. Abdomen elongate, conical, with five visible segments, second segment widest, thence width regularly diminishing to apex, second segment also longest, the remainder decreasing in length. Legs simple. Wings with cell R_1 (marginal cell) closed; R_{4+5} with distinct loop, but less marked than in *Eristalis*; r-m cross-vein before middle of median cell, approximately at one-third of length of cell, slightly oblique; apical portions of M_{1+2} and M_{3+4} parallel to wing border; alula large. Calypters normal. Clothing consisting partly of long pubescence and partly of very short solid scales.

The above generic description is based on Australian specimens, but agrees well with Edwards's description. The position of the genus in the Eristalinae is open to question on account of the position of r-m. The genus is distinguished from *Eristalis* partly on the position of this cross-vein and partly on the head structure.

DISSOPTERA POLLINOSA Edwards.

Dissoptera pollinosa Edwards, 1915, p. 410, Pl. xxxviii, fig. 6.—*Eristalis flavohirta* Klocker, 1924, p. 57, Pl. x, fig. 2.

The description and figure given by Edwards correspond very closely with Klocker's description and figure of *E. flavohirta* and with specimens of a species from various localities in North Queensland.

The peculiar pollinose clothing described both by Edwards and Klocker is very distinctive.

It is possible that this species should bear the name of *Dissoptera heterothrix* de Meijere. Professor Bezzi in a private letter states: "I have one species from Australia; *heterothrix* de Meijere, from Kuranda, Queensland, Dodd, and from Cairns, Illingworth, distinct by the yellow scaly hairs below the usual pubescence". The specimens before me agree exactly with the description and figure of *D. pollinosa* Edwards and differ in several points from the description of *heterothrix* de Meijere. The chief differences lie in the median dark vitta being complete on all the abdominal segments and in the darker posterior femora and tibiae. It is doubtful if these points are of specific importance and it is possible that *pollinosa* should be sunk as a synonym of *heterothrix*. I should doubt the occurrence of two such closely allied forms in Australia.

Hab.—N. Queensland: Dunk Island (Klocker), Cairns District (Dodd), Claudie River (Macgillivray), Townsville (Hill); extralimital.

Subfamily MICRODONTINAE.

Antennae porrect, elongate; arista dorsal, subbasal; eyes bare, wide apart in both sexes; face broad. Wings short; R_5 generally present as an appendix to R_{4+5} crossing middle of cell R_5 (1st posterior cell); M_{1+2} strongly recurrent, apical portion of M_{3+4} bent upwards, r-m cross-vein before middle of median cell.

The genus *Microdon* constitutes the greater part of this subfamily (Brunetti, 1923, p. 307). Apparently all the Australian species should be referred to this genus. One species (*variegatus*) has, however, been referred to *Mixogaster*, but wrongly so, as Knab and Malloch (1922, p. 233) state that "the genus *Mixogaster* . . . . is quite a distinct concept, and apparently confined to America". The same species was originally placed by Walker in the genus *Ceratophya* Macq., but the genus is stated by Knab and Malloch to be "poorly defined and it is extremely doubtful that the Australian species should be referred to it".

Brunetti has proposed a new genus *Paramixogaster* for a species from India, originally described as a *Mixogaster*. In his key this author separates *Paramixogaster* from *Microdon* on the third joint of the antennae being much longer (5-6 times) than the first, whereas in *Microdon* the first is as long as (generally longer than) the third. The type species would appear to be very closely allied to the Australian species, *M. variegatus* Walk., especially in the general wasp-like form and in the antennal proportions. I cannot, however, regard the Australian species as separable generically from *Microdon* on antennal structure alone, since the antennae are so diverse in different Australian species of this genus. One of the new species, *M. hardyi*, has an antennal structure similar to that of *M. variegatus*, but the abdomen is not wasp-like. The extraordinary third joint seen in *M. alcicornis* might be regarded as justification for the separation of this species if the antennal structure is held to be of generic value.

Williston (Manual of N. American Diptera, 3rd Edition) separates *Mixogaster* from *Microdon* on the abdominal structure. But the wasp-like abdomen characterization of *M. variegatus* does not appear to be sufficient reason to separate this species from other Australian species, as *M. hardyi*, which has similar antennae, has nevertheless a typical *Microdon* abdomen. Furthermore, in other genera, e.g. *Cerioides*, the abdomen may be wasp-like or not. Also in other faunal regions, e.g. the Malayo-Papuan, species of *Microdon* have been described with pedunculate abdomen. For these reasons I prefer to regard all the known Australian species as belonging to *Microdon*.

MICRODON.

(For synonymy and references see Brunetti, 1923, p. 307.)

Head broad, somewhat flattened; eyes bare, widely separated in both sexes; face pubescent, gently convex, generally retreating to oral margin, which is not prominent; antennae porrect, arista subbasal, bare. Thorax subquadrate, rather densely pubescent, the derm often minutely punctate and with fine, often indistinct, transverse scratches or striae, giving the thorax a shagreened appearance; scutellum with or without two blunt teeth near apex. Abdomen variable in shape, generally ovate and curved downwards. Legs short and thick, tarsi wide. Wings with characteristic venation, cell R_1 (marginal cell) widely open; R_{4+5} with rudiment of R_5 projecting downwards about halfway across underlying cell; M_{1+2} strongly recurrent, closing cell R_5 (first posterior cell); apical portion of M_{3+4} nearly upright, straight or slightly sinuate, sometimes a stump of a vein present at the angulations of M_{1+2} and M_{3+4}; r-m situated before middle of median cell.

This genus appears to be rather strongly represented in Australia, though the species are, with one or two exceptions, rare and, in several cases, represented by single specimens.

The synonymy is somewhat involved and previous attempts to elucidate it have not been too successful. The present attempt is based on a greater amount of material than has been hitherto available, and even now the identity of one species is obscure. Hardy (1921, p. 15), in his review of the genus, allowed three species—*pictipennis*, *vittatus* and *variegatus*—sinking *M. brachycerus* K. and M. and *Eumerus transiens* Walk. as synonyms of *vittatus* Macq.; *Mixogaster aphritinus* Thomson and *Microdon daveyi* as synonyms of *M. variegatus* Walk.

While much of this synonymy is undoubtedly correct, I do not think that *M. brachycerus* is a synonym of *M. vittatus* Macq., but on the other hand would identify it with the species regarded (as I think, incorrectly) as *M. pictipennis* Macq. The identity of the latter species is uncertain; the description does not appear to correspond with any species before me and I have been compelled to regard it as unknown to me.

Since the publication of Hardy's paper a further species—*M. nigromarginalis*—has been described by Curran and Bryan; this is represented in Australian collections, but has generally been confused with *M. brachycerus* under the name *M. pictipennis*.

In the present paper no less than eleven species are proposed as new. This is probably only a small part of the number to be found, as the western parts of the continent are not represented by any known species.

Distribution.—The species are distributed along the eastern coast of Australia including Tasmania. While some are represented by single specimens, others are known to have a wide range, e.g. *M. nigromarginalis* ranges from Queensland to southern New South Wales, *M. variegatus* from Queensland to South Australia and *M. brachycerus* from Queensland to Tasmania. *M. vittatus* occurs from New South Wales to Tasmania, *M. chalybeus* is known from Queensland, Victoria and probably Tasmania, and *M. alcicornis* from Queensland, New South Wales and possibly Tasmania. *M. dimorphon* is known from Western Australia, South Australia and Queensland; *M. modestus* from Queensland, New South Wales and Western Australia and *M. nicholsoni* from Queensland and New South Wales. *M. amabilis* is recorded only from Queensland; *M. barringtonensis*, *M. waterhousei* and *M. macquariensis* from New South Wales; *M. hardyi* from Tasmania and *M. occidentalis* from Western Australia.

Life History.—Two of the Australian species, *variegatus* and *brachycerus*, are known to breed in association with ants and the larvae and pupae have been described by Knab and Malloch. Recently Mr. Nicholson has bred the former species in some quantity from pupae found beneath the bark of a tree in association with ants. The larvae of an unidentified species have been sent me from Victoria by Mr. Barrett, the specimens having been taken in an ant's nest.

Mr. Bertram of Sydney has also succeeded in breeding out *M. nigromarginalis* C. and B. from pupae found in a fallen tree trunk in cavities in the wood, the larvae and pupae being definitely associated with ants. It is probable that the other species will also be found to pass their larval and pupal stages in ants' nests or run-ways, but the peculiar and striking pattern of *M. waterhousei* suggests a possible association with some species of wasps.

Mr. Clark, of Perth, has recently sent me specimens of *M. dimorphon* bred from pupae found in the nests of species of *Iridomyrmex*.

Measurements.—In the measurement of the antennal proportions the same ocular micrometer has been used with the same combination of lenses. The relative proportions of all the antennae are, therefore, comparable. Each division of the ocular micrometer is equivalent to 0·066 mm. with the lenses used, and this factor may be used to multiply the figures given if the actual lengths of the joints are required.

Table of Species of Microdon.

1. Abdomen pedunculate, wasp-like .... *M. variegatus* Walk.
   Abdomen not pedunculate 2
2. Third antennal joint bifurcate .... *M. alcicornis*, n. sp.
   Third antennal joint simple 3
3. Scutellum dentate 4
   Scutellum simple, at most sulcate at apex 6
4. Third antennal joint much longer than first; antennae long (12 : 2 : 34) .... *M. hardyi*, n. sp.
   Whole antennae short 5
5. Dull brown or blackish species (4 : 2 : 9) .... *M. brachycerus* K. & M.
   Metallic-blue species (4 : 3 : 5) .... *M. nicholsoni*, n. sp.
6. First antennal joint longer than third, antennae long 7
   First antennal joint at most as long as third, generally shorter, antennae short .. 8
7. Dull brown species with inconspicuous clothing (15 : 3 : 13) .. *M. macquariensis*, n. sp.
   Brightly coloured species with bright orange transverse bands on abdomen (20 : 6 : 14) .... *M. waterhousei*, n. sp.
8. Tufts of bright golden pubescence present on mesonotum and pleura, antennal proportions (10 : 2 : 10) .... *M. amabilis*, n. sp.
   No such tufts of pubescence present 9
9. Third antennal joint elongate with concave upper surface 10
   Third antennal joint elongate ovate 12
10. Blue species with blue venter 11
    ♂ blue with blue and yellow abdomen; ♀ black .... *M. dimorphon*
11. Third joint strongly upturned at extremity (8 : 2 : 20) .... *M. occidentalis*, n. sp.
    Third joint gently concave on upper surface (4 : 2 : 16) .... *M. chalybeus*, n. sp.
12. Scutellum with thick fringe of erect black hair along apical margin .... *M. nigromarginalis* C. & B.
    Scutellum with yellow pubescence, not forming a distinct fringe 13
13. Scutellum dark, apex sulcate .... *M. modestus*, n. sp.
    Scutellum pale brown or testaceous, apex not definitely sulcate 14
14. First two antennal joints black, relative antennal proportions 5 : 2 : 7 .... *M. vittatus* Macq.
    First two antennal joints reddish brown, relative antennal proportions 7 : 3 : 9 .... *M. barringtonensis*, n. sp.

M. pictipennis Macq. is omitted from the above table as unknown to me.

MICRODON VARIEGATUS Walker. (Plate xiv.)

Ceratophya variegata Walker, 1852, p. 220, Pl., fig. 6.—*Mixogaster aphritinus* Thomson, 1868, p. 491.—*Microdon daveyi* Knab and Malloch, 1912, p. 233.—*Microdon variegata* Hardy, 1921, p. 15.

The above synonymy is given on the authority of Hardy (1921) and appears to be certainly correct. Among the extensive series of specimens before me I can only recognize a single species with pedunculate, wasp-like abdomen. Knab and Malloch discuss the question of the generic separation of this species from *Microdon*, but conclude that there is no adequate reason for it. The point has already been dealt with in this paper and need not be elaborated here.

The very long third joint of the antennae is paralleled in *Paramixogaster vespiformis* Brunetti of India, but a similar structure occurs in *Microdon hardyi*.

The relative proportions of the three joints is somewhat variable; measurements of a series gave the following results:

Specimen.		1st joint.	2nd joint.	3rd joint.
Sydney,	♂	8	1	32
,,	♂	11	1	46
,,	♀	11	2	36
,,	♀	11	2·5	35
,,	♀	11	3	30
,,	♀	12	2	39
N.S.W.,	♀	12	2	35
,,	♀	10	2	31
Illawarra,	♂	11	1	52
Blue Mts.,	♂	12	2	37
Woy Woy,	♂	11	1	48
,,	♂	12	2	50
Brisbane,	♀	10	2	16
,,	♀	11	2	33
,,	♀	11	3	30
S. Australia,	♀	10	2	27
Victoria,	♀	12	3	31
,,	♀	12	4	30
,,	♀	10	2·5	25
,,	♂	11	2·5	27
,,	♂	11	2	35
,,	♀	11	2·5	29
,,	♂	11	1·5	38
,,	♀	11	3	28
,,	♂	11	2	42
,,	♀	12	3	29
,,	♀	11	3	25

The species appears to be widely distributed along the eastern coast, from Victoria to as far north as Brisbane, while one specimen is before me from South Australia.

The larvae and pupae occur in ants' nests and the puparium has been described by Malloch and Knab. The following description is taken from these authors: "The puparium is of the shape usual in *Microdon*, elongate-elliptical, nearly straight side with very slight indications of constrictions near middle, strongly convex, the ventral surface (by which it is attached) perfectly flat, colour ferruginous yellow, the margin slightly darker, thoracic horns ferruginous brown, posterior respiratory horn reddish brown, pruinose; the dorsal surface shows a median longitudinal crease extending the entire length to the posterior respiratory tubercle; on each side of this the surface is broken into reticulations, larger and forming fairly regular rows towards the middle, somewhat smaller and more irregular towards the sides, there being about ten longitudinal rows on each half; the surface is granular and the reticulations are produced by rows of closely approximated minute, white, tuberculated spines; the surface between the reticulations is somewhat depressed; the posterior respiratory tube is somewhat thickened at the base, with a dorsal basal swelling, bluntly rounded at the tip, the surface coarsely granular.

"Length 8·5 mm., width 5 mm., height 3 mm.".

I am indebted to Mr. A. J. Nicholson for permission to publish the accompanying photographs (Plate xiv) of the fly and its puparium which were taken by him at Lindfield, Sydney.

MICRODON ALCICORNIS, n. sp.

A blackish species with bifurcate antennae.

♂. Head black, front black with faint green sheen, very broad, wider than the width of an eye, closely punctate, a triangular area around and in front of ocelli, laevigate, with few punctures; pubescence mainly dark, but white in front and on vertex; face reddish-brown, subquadrate, moderately closely punctate and with rather dense white pubescence; cheeks black and with white pubescence; eyes bare. Antennae black, of extraordinary form, first joint cylindrical, about two and a half times the length of the small second joint; third joint very large, much longer than the other two joints together, biramate, the upper branch curving upwards and then forwards, the lower forwards and then upwards to end on a level with tip of upper branch, the junction of the two branches rounded, not angulate, both branches thick, but the lower considerably the thicker, the upward-turned portion thinner and somewhat rotated; arista stout, arising at base of fork, slightly to outer side and ending within the space enclosed by the branches; relative proportions of joints 5:2:30.

Mesonotum black, punctate and finely strigose in places, giving an appearance of shagreen; pubescence mainly dark, some light pubescence present on sides, as a feeble band along transverse suture, and as another band along posterior margin. Scutellum dark, punctate; pubescence mainly dark with some light hairs intermingled. Pleurae mainly black, with pale pubescence. Abdomen not markedly constricted at base, closely granulate, reddish-brown, darker at base, the first segment black, pubescence mainly dark, white patches present along the apical margins of second and third segments in outer half, extending on to adjacent laterobasal angles of third and fourth segments respectively, a small obscure pale band on each side of base of second, a pale patch on each side of mid-line at apex of fourth.

Legs with coxae, trochanters, basal two-thirds of femora and tarsi black, the apical third of femora and all the tibiae yellowish-brown.

Wings grey, more darkly suffused along the veins; venation normal, stump of R_3 present. Calypters white; halteres brown with yellow clubs.

Length, 8 mm.

Hab.—New South Wales: Como, 18.10.25 (Nicholson). Type in Macleay Museum. A second male is in the South Australian Museum labelled Tasmania, Simson, 2772.

Mr. Hardy informs me that he has seen the species from Queensland.

The antennal structure is most extraordinary, but I do not think sufficient to justify the erection of a new genus, as in all other respects the species is in agreement with other Australian species of *Microdon* and the antennae are most variable in the genus.

MICRODON HARDYI, n. sp.

♂. Black and ferruginous species with long antennae. Head black, front broad, about half as wide anteriorly as at vertex, black with dark pubescence; face testaceous in centre, becoming ferruginous above and at sides, rather densely clothed at sides and below with whitish hairs; cheeks and occipital region with similar hairs. Antennae black; first joint moderately long, rather slender; second

very short; third joint very long and thick, the outer margin irregularly sinuate; arista shorter than the segment, arising from a small puncture near extreme base and on outer surface; a small pit is present on outer surface below and beyond the insertion of arista; relative lengths of joints 12:2:34.

Thorax dark brown, slightly iridescent, more testaceous at sides and base with rather long appressed straw-coloured pubescence, denser across mesonotum in front of suture and at posterolateral angles. Scutellum dark testaceous, apex slightly grooved with a short tooth on each side of groove, clothed with yellowish pubescence. Postnotum black; pleural segments testaceous, becoming darker below with rather long yellowish pubescence in middle.

Abdomen ferruginous, somewhat darker towards apex, not greatly constricted at base, clothed with fine short dark pubescence, with longer white hairs irregularly arranged on each side of mid-line on second segment, forming a transverse patch on each side of apex of third extending along lateral margins, a band along lateral and an irregular patch at each side of apex of fourth segment; longer white pubescence present on lateral margin of second segment at base; under surface testaceous with white pubescence.

Legs testaceous, the basal two-thirds of femora, excepting extreme base, black, posterior metatarsi thickened.

Wings smoky-grey, somewhat lighter in basal cells.

Length, 9 mm.

Hab.—Hobart, January, 1924 (G. H. Hardy).

MICRODON BRACHYCERUS Knab and Malloch.

Microdon brachycerus Knab and Malloch, 1912, p. 235.—*M. pictipennis* Hardy, 1921, p. 15, *nec* Macquart, 1850, p. 129.

This species is certainly distinct from *M. vittatus*, but appears to be referable to that recorded by Hardy under the name *M. pictipennis* Macq.

The colour varies somewhat in different specimens; a Tasmanian specimen agrees well with the original description, but mainland specimens are as a rule darker with practically black abdomen. A series of Queensland specimens in the Macleay Museum are, however, lighter and correspond with the Tasmanian specimen.

The species may be recognized from other Australian species by the combination of dark nonmetallic colour, short antennae and dentate scutellum. The relative antennal proportions are given by Knab and Malloch as 3:1:16. This seems certainly an error, as antennae with such proportions could not be described as "short and stout"; I believe that the 16 is probably a misprint for 6,* which agrees with the proportions in the specimens before me.

The larvae and pupae have been found in ants' nests and the puparium described by Knab and Malloch: "The puparium is of the shape usual in this genus—elliptical, strongly convex, flattened beneath where it is attached to a stone or other surface. The colour is dull yellowish-brown, obscured by irregularly attached particles of earth; the anterior pupal respiratory horns and the posterior larval ones are ferruginous; posterior respiratory tubercle bifid at tip. The dorsal surface is nearly smooth and shows none of the usual reticulations, but instead is studded with scattered prominent brown tubercles (somewhat obscured

* This surmise has been proved correct by a recent letter from Mr. Malloch, dated 24th February, 1926.

by the attached particles of earth). Length 7 mm.; width 5·5 mm.; height about 3 mm".

Hab.—Tasmania: Hobart, Zeehan; New South Wales: Sydney, Blue Mountains; Queensland: Rockhampton.

MICRODON NICHOLSONI, n. sp.

♀. Head black with slight bluish and greenish iridescence; front parallel-sided (about half the eye width), with dark hairs, a narrow line of pale pubescence present along orbital margin in lower part of front; face retreating towards mouth, practically parallel-sided, but very slightly narrower than front, with mingled dark and pale hairs, the dark hairs predominating above; cheeks narrow with scanty pale pubescence; occipital margin with black hairs; antennae stout, black, the second and third joints with dense grey pubescence; first joint narrow at base, widened towards apex; second shorter than first, but wider at apex; third slightly longer than first, rounded, almost orbicular, arista stout, longer than joint, set on outer surface near base, with a groove extending frontwards along outer side; relative proportions of joints 4:3:5 (*vix*).

Mesonotum black, iridescent on disc, with black pubescence; scutellum dark blue-black, a small tooth present on each side of apex, almost obscured by rather long black pubescence with which a few paler hairs are intermingled; pleural segments black shining, some black hairs in anterior portion. Abdomen deep blue with short black pubescence, longer at sides of base, first segment narrow; second slightly widened from base to apex; third and fourth broad but gradually decreasing in width towards apex; venter blue-black. Legs reddish-yellow, coxae, trochanters, and basal third of femora shining black, tibiae with a narrow oblique black ring in outer third, this ring covering a scar-like impression on the posterior tibiae; tarsi somewhat infuscate; pubescence mainly dark, with some golden hairs on tibiae and dense golden pubescence on under side of tarsi. Wings grey, slightly suffused with darker along the veins; venation as in genus, the projection from R_5 well marked extending half way across the cell R_5, the rudiment of M_2 also present. Halteres light yellow.

Length, 9 mm.

Hab.—New South Wales: Woodford (15.11.25, Nicholson). Holotype in Macleay Museum. Described from a single ♀ recently captured by Mr. Nicholson by sweeping. There is another specimen in the Macleay Museum which may belong to the same species, but it is badly mutilated and the abdomen missing; it agrees with *nicholsoni*, except that the scutellar pubescence is almost entirely pale and the wings are practically clear. This can hardly be *pictipennis* Macq., as there is complete absence of any pale clothing on thorax or abdomen. The form of the third antennal joint is unlike that of any other known Australian species.

VAR.: A specimen from Queensland may represent a variety or even a distinct species.

♀. Differs in the presence of white pubescence forming distinct bands on the apical margins of the 3-5 abdominal segments, these bands being interrupted in the middle line; in the pale pubescence on the face extending to base of antennae and in the lighter yellow colour of the basal half of the tibiae.

Hab.—Queensland: Mt. Tambourine (H. Hacker, 28.10.11).

This form agrees rather closely with the description of *M. pictipennis*, except that the wings are not very markedly suffused and the basal antennal joints are not testaceous.

MICRODON MACQUARIENSIS, n. sp.

A brownish species, the abdomen marked with patches of white pubescence.

♂. Head brown, front dark brown, blackish in centre and around ocelli, with pale yellow pubescence, about twice as wide at vertex as anteriorly; face convex, light brown, darker above and at sides, densely clothed with white pubescence; cheek similar. Antenna comparatively long, first joint black, elongate, almost as long as second and third joints together, slightly laterally compressed; second joint short, broadened at apex, black; third joint stout, the upper surface somewhat concave, yellowish-brown at base, the rest blackish, four times as long as second joint, the relative proportion of the three joints being 15:3:13, arista arising near base. Eyes bare. Mesonotum dark brown, almost black on disc, the humeral angles and lateral margins light yellowish-brown, pubescence short, mostly dark, but with some ill-defined patches of yellowish pubescence only visible from certain directions. Scutellum light brown, darker at base, with dark pubescence and an apical fringe of yellow pubescence. Pleural segments pale grey, almost white in upper portion, dark brown in lower; pubescence white. Abdomen dark brown with dark median vitta and lighter patches. Second visible segment with pale areas on each side of basal margin and along apical margin, those areas interrupted in middle line, pubescence black on dark areas, white on pale areas; third segment with anterolateral angles and lateral margins pale, and a pale area on each side extending as a longitudinal band on each side of median vitta, then as a transverse band along posterior margin; fourth segment similarly marked, but longitudinal limb of L longer than transverse. These pale areas clothed with white pubescence, the rest with dark; fifth segment pale brown; venter pale brown with white pubescence. Legs pale brown, the basal two-thirds of the femora blackish; the metatarsi not markedly thickened. Wings hyaline without shading along veins; venation normal. Calypters white with pale margins. Halteres pale yellow.

Length, ♂. 9 mm.; antennae 2 mm.

Hab.—New South Wales: Dubbo (24.4.24).

Described from a single ♂ taken by myself on the golf links at Dubbo.

The arrangement of the pale pubescence on the thorax is hard to make out, as from above all the hairs appear dark, but when viewed from in front a large patch of yellow pubescence is evident in the anterior and outer portion in front of suture; viewed from behind the yellow pubescence appears to extend across the base and forwards on each side of the middle line.

The species is somewhat similar in appearance to *M. vittatus* Macq., but *inter alia* differs widely in the proportions of the antennal joints.

MICRODON WATERHOUSEI, n. sp.

Black, iridescent, with two broad reddish-orange abdominal bands.

♀. Front broad, black, iridescent, with golden pubescence and some blackish hairs around the ocelli; face convex, slightly narrower below than above, dark greenish, iridescent, with dense white pubescence, the upper lateral portion with gold pubescence descending from front; cheeks with white pubescence; upper portion of occipital margin with golden, the rest with whitish pubescence. Antennae black, long, the first joint very long and slender, as long as second and third combined; second joint short; third joint about twice as long as second joint and two-thirds as long as first, stout elongate, ovate, with a deep groove along the upper and outer surface, and a small pit near apex on same surface; arista arising near base, shorter than joint; relative proportions of joints 20:6:14. Eyes

bare. Mesonotum blackish, with coppery, purple and violet iridescence, finely strigose; the presutural portion densely clothed with orange pubescence, extending along each lateral margin in a narrow line to merge into a large triangular prescutellar patch of same colour; clothing between the two orange patches black and more scanty; scutellum iridescent, with dense orange pubescence. Pleurae black with dark green iridescence, pubescence whitish, except on propleura, where it is golden. Abdomen elongate, subparallel-sided; first visible segment greenish iridescent; second segment violet iridescent at sides, greenish iridescent in centre with orange pubescence; third segment orange with a small greenish iridescent area at base, the whole clothed with deep orange pubescence, denser in the posterior portion of the segment; fourth segment longer, convex, the greater portion black with violet iridescence and clothed with black pubescence, a narrow lateral band and approximately about the posterior quarter of the segment orange with dense orange pubescence; fifth segment black with orange pubescence along sides. Venter black, the two basal segments narrowly orange, pubescence whitish. Legs brown, the basal half of femora and coxae black; posterior metatarsi strongly incrassate, the other metatarsi less so. Wings grey, suffused with brown along the anterior margin and along the veins; venation as in genus. Calypters white with brown margin. Halteres yellow.

Length, ♀. 12 mm.

Hab.—Killara, Sydney (12.2.25).

The unique specimen of this fine species was captured by Dr. G. A. Waterhouse, in the grounds of his home "Allowrie", in Killara. When taken it was hovering in front of the trunk of a tree as if seeking a hole. From the distinctly wasp-like scheme of colouring and from its actions, it seems probable that the species may be found to be parasitic in the larval stage on some species of wasp.

The richly coloured clothing renders the species quite distinct from any other described from Australia, while the proportions of the antennal joints are also distinctive.

Holotype presented to the Australian Museum.

MICRODON AMABILIS, n. sp.

A small dark species with brilliant golden pubescent tufts.

♀. Head black; front between one-third and one-fourth the total head width, sides parallel above, divergent anteriorly, black feebly iridescent, pubescence black, a few golden hairs on each side in front of middle; face somewhat wider than front, mainly metallic green iridescent, violet about base of antennae with a median, black, laevigate vitta from antennae to beyond middle, violet around oral margin, clothed with bright golden pubescence, except on black portion of median line and around oral margin, some white pubescence along orbits between eye margin and the golden pubescence; cheeks dark; posterior orbits with grey pubescence in lower half, black on upper and on vertex. Antennae black, rather slender, first joint elongate, slender, cylindrical; second short; third as long as, but broader than, first, obtusely rounded at apex and flattened; arista short, subbasal, on outer flattened surface; relative proportions of joints 10:2:10.

Mesonotum black, feebly iridescent, the anterior margin and humeral angles metallic green iridescent, a greenish patch present in front of scutellum, lateral margins violet iridescent; pubescence black, a dense tuft of bright golden pubescence on greenish area in front of scutellum. Scutellum metallic-green, with rather sparse greyish pubescence, more golden at base; apex rounded, not dentate. Pleural segments violet, greenish on mesopleuron, with a tuft of dense golden

pubescence on mesopleuron extending on to humeral angles; pubescence elsewhere scanty, whitish. Abdomen dull blackish, closely granulate, pubescence mainly short and black, some longer white hairs present at base of second segment, as an indefinite oblique line on each side of fourth segment in apical half and on the lateral margins of the second to basal half of fourth segment; venter black. Legs black, femora feebly iridescent, knees narrowly brownish; moderately long and thin, the posterior metatarsi long but distinctly broadened; pubescence mainly white. Wings hyaline, veins brownish, venation normal. Calypters pale brown with blackish margins; halteres yellow.

Length, 6·5 mm.

Hab.—Brisbane (26.2.19, H. Hacker). A single female in the collection of the Queensland Museum. A lovely little species, quite distinct from other Australian species and readily recognized by the tufts of dense golden pubescence.

MICRODON OCCIDENTALIS, n. sp.

A metallic-blue species very similar to *M. chalybeus*, but with different antennal proportions.

♀. Head broader than in *M. chalybeus*, front broad, about half head width, parallel-sided, moderately closely punctate, dark blue in colour, pubescence dark; face convex, retreating towards oral margin, blue-black, pubescence dark above, longer and paler below, some greyish tomentum on parafacials. Antennae longer than in *M. chalybeus*, first joint cylindrical, second very short, third joint long, considerably longer than in *M. chalybeus*, strongly curved in middle, the apex directed upwards, a slight thickening at extreme base; arista basal, shorter than length of joint; the whole antennae black; relative proportions 8:2:20.

Thorax, abdomen and legs as in *M. chalybeus*; wings with veins distinctly suffused with brown.

Length, 9 mm.

Hab.—Western Australia: Warren River (W. D. Dodd).

Described from a single female in the South Australian Museum collection.

The species is close to *M. chalybeus*, but abundantly distinguished by the antennal structure, which shows a distinct approach to the type found in *M. alcicornis*.

MICRODON CHALYBEUS, n. sp.

A metallic-blue species with reddish legs.

♂. Head deep blue, forehead about one and a half times the width of an eye, rather sparsely punctate, deep blue around ocelli, greenish iridescent anteriorly, pubescence pale in front and on vertex, elsewhere dark; face convex, sides slightly divergent, rather sparsely punctate, deep blue, with pale pubescence; cheeks black with pale pubescence; eyes bare. Antennae black; first joint short; second joint very short; third joint long, thickened, especially at base, and somewhat curved, the upper surface distinctly concave, arista stout, rising near base, shorter than segment, a shallow groove on outer surface of third joint below arista; relative proportions of joints 4:2:16. Mesonotum black on disc, blue at sides, the black portion slightly iridescent, finely and rather sparsely punctate with some fine transverse striae; pubescence long, dark, with paler hairs intermingled, especially at sides. Scutellum deep blue, pubescence mainly pale, apical margin rounded, not dentate. Pleurae blue with pale pubescence. Abdomen deep blue, the first segment black, laevigate, the remainder rather closely and finely granulate, pubescence short, dark, appressed, longer pale hairs extending along the

lateral margins of the whole abdomen, and forming a small patch on each side of base of second segment. Venter blue. Legs light reddish-yellow, the coxae, trochanters and tarsi black, the latter with yellow pubescence beneath. Wings grey, slightly darker along veins, venation normal, M_1 and M_3 somewhat sinuous, stump of R_5 present. Calypters white; halteres yellow, brownish at base.

♀. Differs from male mainly in the entire absence of pale pubescence; the third antennal joint is somewhat less thickened at base.

Length, 8 mm.

Hab.—Type (no locality); allotype, Brisbane (G. H. Hardy, August, 1925); paratypes 2 ♂, Brisbane (H. Hacker, 4.9.11, 24.9.23), ♂ Stradbroke Is. (J. W. Boreham, October, 1891), Tasmania (Simson 2711), ♀ Victoria, Warburton, 1.20 (F. P. Spry).

In the paratypes, M_1 is quite straight not sinuous, and it is possible that, if this is constant, the southern specimens should be separated from the northern; as in other respects they agree, it would be rash to separate them without further evidence.

In one wing of the Victorian specimen, R_5 extends completely across the underlying cell to join M_{1+2}.

The species is apparently close to *M. coeruleus* from India, but the scutellum is not dentate; judging from Brunetti's figure, the antennae must be very similar, but the first joint longer.

The species might conceivably be *M. pictipennis* Macq., but there are several discrepancies in the description, notably that the face in the female is not clothed "à petits poils blancs", and the first two joints of the antennae are not "testacés". It is unfortunate that the third joint was missing in Macquart's type.

MICRODON DIMORPHON, n. sp.

♂. Head black with faint bluish sheen in parts; front very broad, one and a half times as wide as an eye, ocellary region laevigate with some dark hairs, bounded by an oblique line on each side anteriorly; lateral portions of front depressed, slightly punctate, with long straw hairs, the median line subcarinate, laevigate; face broad, retreating towards mouth and sloping from middle towards eyes, with long pale-straw hairs. Antennae slightly longer than head, stout, black; first joint slender, subcylindrical; second very short, little wider than first, third very stout and concave on upper and outer surface, the arista, which is stout, arising at the base of this surface (6:2:12). Mesonotum black, iridescent, clothed with long, straw-coloured pubescence, rather denser at sides; scutellum black with faint bluish tinge, with punctures rather sparse, with erect straw-coloured pubescence, thicker along the free border, apex feebly sulcate; pleural segments black with long pale pubescence in anterior portion.

Abdomen not greatly constricted at base, the first segment black, short; second segment mainly blue-black with or without a reddish-brown apical border not extending across mid-line, widened from base to apex; third and fourth segments gradually but only slightly decreasing in width towards apex, reddish-brown with a central blue-black vitta, continuous with that colour on second segment, interrupted before apex of third segment and not extending beyond middle of fourth; pubescence long and pale on sides and along the apical margins of segments, but interrupted in mid-line, rest of dorsum with shorter dark appressed hairs. Venter reddish-brown with pale pubescence. Legs reddish-brown, the coxae, trochanters, basal third of femora, apical third

of tibiae and tarsi black; posterior metatarsi stout. Wings clear, pale grey, not suffused along veins; halteres yellow.

♀. Larger than male, entirely black except the legs; the thorax slightly iridescent; clothing mainly black, except on face, lower portions of pleura and abdominal segmentations; legs coloured as in male. Front as wide as in male; antennae similar, the third joint very slightly shorter.

Length, 7-10 mm.

Hab.—Western Australia: ♂ ♀ Mundaring, Armadale (J. Clark); ♀ South Australia (Macleay Museum). ♂ Queensland: Stanthorpe (F. A. Perkins, 26.9.22).

The sexes are so different in appearance that when only the Queensland male and the South Australian female were available they were thought to represent two different species. The receipt of a series from Mr. J. Clark from Western Australia clearly shows that they are the sexes of one species, and the puparia are also identical.

The Queensland male is rather brighter than the type and the blue colour of thê second abdominal segment more obvious; other Western Australian males are as brightly coloured as the Queensland male. The punctures on the front are perhaps slightly longer in the Queensland specimen and the thoracic pubescence rather larger; the differences do not appear specific and are hardly definable. The type is apparently slightly dusty, but is otherwise in better condition than the other specimens; all the Western Australian females appear somewhat greasy.

The species approaches close to *M. chalybeus*, but the antennal proportions are somewhat different and the colour is also distinctive. The puparium is of the normal shape characteristic of the genus and is of a light testaceous colour; there are fôur rows of dark brown, feebly granulose obtuse tubercles, one along each side of the dorsum composed of six tubercles and one above each lateral margin composed of seven tubercles.

The posterior spiracles are dark brown at base, light brown and laevigate at apex, which is feebly bifid.

Specimens have been reared by Mr. Clark from pupae found in the nests of *Iridomyrmex rufoniger*, *I. gracilis* and *I. discors*. Two specimens were taken in a nest of *I. rufoniger* in a termitarium of *Eutermes* sp. An unhatched puparium taken by Mr. Davey in Victoria in a nest of *Iridomyrmex nitidiceps* apparently belongs to the same species.

Concerning this species Mr. Clark writes: "I spent a whole afternoon watching females depositing their eggs. They are, or appear to be, the most clumsy insects I know; they seem to be too lazy to fly more than a few feet, then tumble to the ground. The ants take no notice of them".

MICRODON NIGROMARGINALIS C. & B.

Microdon nigromarginalis Curran and Bryan, 1926, p. 132.

The description of this species agrees well with a fairly common and widely distributed species that has hitherto been confused in collections with *M. brachycerus* under the name *M. pictipennis**.

Only the female was known to Curran and Bryan; in the male the front is strongly constricted about midway between the ocelli and antennae with a shallow groove at narrowest part. Also the light pubescence on the thorax is golden instead of silvery, as in the female. This species has recently been

* The identification has been confirmed by the receipt of a paratype from Mr. Bryan.

bred by Mr. Bertram from pupae obtained from cavities in a fallen log where they were living in association with ants. The puparium is of the usual shape, elongate-elliptical, convex with flattened ventral surface; light brown and covered with small granules, somewhat obscurely arranged in clusters and in a somewhat longitudinal direction; the margins are fimbriated; the posterior spiracle is coloured as the dorsum, longitudinally corrugated with a feebly bifid apex on each side of which are situated the shining reddish-brown spiracles; the anterior respiratory horns are black and set with small spinose denticles.

Length 7 mm., width 4·5 mm., height about 2·5 mm.

Hab.—New South Wales: Kosciusko, Sydney, Blue Mountains; Queensland: Brisbane, Pt. Curtis, Rockhampton, Eungella (Mackay).

MICRODON MODESTUS, n. sp.

A small obscure species allied to *M. vittatus*.

♂. Head black, front narrowed in front of middle, thence widened to face, width at vertex one-fourth total head-width, at narrowest part about one-tenth head-width, black with bronzy reflections, pubescence dark, some pale pubescence on orbits on each side of antennae; face convex, parallel-sided, somewhat broader than front at its widest part, black with bronzy reflections in centre, greenish-bronze at sides, pubescence rather dense, pale; posterior orbits with scanty pale hairs. Antennae black, first joint short, second about half length of first, third briefly elongate, ovate, equal in length to other two joints, apex obtuse, arista arising from outer and upper surface near base, an obscure longitudinal groove on outer surface below arista; relative proportions approximately 3·5:1·5:5. Mesonotum black with greenish-bronze reflections, except humeral angles and postero-lateral ridge which are black with faint blue sheen; finely and rather sparsely punctate; pubescence rather short, pale. Scutellum similar to mesonotum, green-bronze, with fine punctures, and rather fine pale pubescence, apex rather strongly sulcate, but not dentate. Pleurae black with greenish iridescence; pubescence pale, scanty. Abdomen blackish-brown, second to fourth segments with pale straw-coloured pubescence, that on second forming a wide band at sides, very narrow along apical margin, that on third broader at sides, but hardly interrupted in mid-line, that on fourth covering most of surface except on a broad basal band. Venter brown with pale pubescence. Legs brown, femora black at base, the black more extensive on the intermediate and posterior femora, being continued along dorsal surface nearly to knees; tibiae slightly infuscated about apical third, tarsi also somewhat darker, especially the posterior. Wings grey, veins brown, hardly suffused; venation normal. Calypters and halteres yellowish.

Length, 5 mm.

Hab.—Queensland: Brisbane (25.9.19, H. Hacker).

♀. Similar to male, front two-sevenths of head-width at vertex, sides divergent anteriorly, with more extensive straw-coloured pubescence in front; face slightly narrower than front and slightly narrowed to oral margin. Antennae slightly longer, relative lengths of joints 4:2:8. Thorax similar. Abdomen somewhat lighter brown, fourth segment with complete apical band of pale pubescence; fifth segment with apical patch of pale pubescence. Legs lighter brown, the black area on femora less marked and the tibiae and tarsi hardly infuscated.

Length, 8 mm.

Hab.—New South Wales: Hunter River, Yass (Macleay Museum).

A small obscure species related to *M. vittatus* but differentiated by the dark scutellum with grooved apex, and by the arrangement of the abdominal pubescence.

There is also some difference in the antennal proportions, but the structure is similar in the two species.

I believe that the above ♂ and ♀ are correctly placed as sexes of but one species, though the localities from which they come are rather far apart, and though there are differences, these are probably of a sexual nature. In general appearance the species resembles *M. nigromarginalis* but lacks the upturned fringe of black hair on the free border of the scutellum.

A specimen (♂) of this species has recently been received from Perth, W.A. (J. Clark).

MICRODON VITTATUS (Macq.).

Aphritis vittatus Macq., 1850, p. 129.—*Eumerus transiens* Walk., 1852, p. 225.—*Microdon vittatus* Hardy, 1921, p. 15.

Hardy places *Microdon brachycerus* Knab and Malloch as a synonym of this species, but this is certainly incorrect.

Specimens corresponding with Macquart's and Walker's descriptions are before me from Tasmania, Victoria and New South Wales. The species should be readily recognized from most other Australian species by the combination of short antennae, nonmetallic colour and unarmed scutellum. *M. nigromarginalis* C. & B. is closely allied, but differs *inter alia* in the dense black apical pubescence on the scutellum. The following species is more closely related but is, I think, distinct; the differences are discussed under *M. barringtonensis.*

The first antennal joint is nearly the length of the third; Hardy (1921) gives the relative lengths of the three joints as 0·5 mm., 0·2 mm., 0·5 mm. The short series before me show the following proportions in different specimens: Zeehan, Tasmania, ♂ 5:3:6; Barrington Tops, N.S.W., ♂ 5:2½:7 (3 specimens), ♀ 5:2½:8; Fern Tree Gully, Victoria, ♀ 5:3:8; Gippsland, Victoria, ♂ 5:3:8; small ♂, no location, National Museum, 4:2:6.

The Barrington Tops specimens are somewhat smaller than the Tasmanian and Victorian specimens, but do not appear to differ in other details.

The wing venation differs from that of *M. barringtonensis* in that the apical portions of M_{1+2} and M_{3+4} are much less sinuate but more strongly recurved and show fewer rudimentary veinlets.

Hab.—Tasmania, Victoria, New South Wales.

MICRODON BARRINGTONENSIS, n. sp.

A medium-sized brownish species, closely allied to *M. vittatus* Macq., but with different antennal proportions.

♂. Head black; front narrowed in front of ocelli, sides thence slightly divergent, a shallow depression across narrowest part, black, obscurely ferruginous across middle and at sides, rather sparsely punctate, with black hairs intermingled with golden in front and on vertex; face gently convex, black, becoming ferruginous towards sides, rather densely clothed with golden pubescence; cheeks black. Antennae with first two joints ferruginous, densely black-haired, third joint black, all the joints short, the third slightly longer than the first and ovate, arista longer than third joint; relative proportions of joints 7:3:9. Mesonotum black on disc, iridescent, humeral angles and sides before suture yellowish-brown, sides and posterolateral angles darker brown, more ferruginous; pubescence mainly golden, but dark hairs present in places, more particularly behind suture. Scutellum dark ferruginous, laevigate, sparsely punctate, with dark pubescence above, and golden hairs along face border; apex rounded, not

dentate. Pleurae yellow-brown; pubescence golden, black on mesopleuron. Abdomen ferruginous with an obscure darker median vitta mainly with appressed dark pubescence, but with areas of pale yellow pubescence over greater part of second segment, as a triangular patch on each side of middle line at apex of third and fourth segments and along lateral margin of third segment. Venter ferruginous with rather sparse pale pubescence. Legs reddish-brown or ferruginous with ill-defined blackish patch on middle third of femora, a transverse somewhat oblique scar crossing femora at basal third, a similar scar present at apical third of tibiae; pubescence mainly dark, pale on coxae and basal third of femora, bright orange on under surface of tarsi.

Wings clear, faintly greyish, the veins lightly suffused with dark grey; venation as in genus, but apical sections of M_{1+2} and M_{3+4} strongly sinuate with well marked projecting rudiments of veinlets. Calypters and halteres yellow.

Female agrees with male, but forehead wider and hardly contracted in front of ocelli, there being no sulcus across middle.

Length, ♂, ♀ 10 mm. (Approximately, as the abdomen is bent under in both sexes.)

Hab.—New South Wales: Barrington Tops, February 25 (Sydney University Zoological Expedition), 2 ♂, 1 ♀.

Type in Macleay Museum.

This species, though unquestionably close to *M. vittatus*, appears to be distinct. The main differences are the larger size, reddish-brown basal antennal joints, different relative proportions of joints, the more lightly pictured wings, the somewhat different venation. In *M. vittatus* the pale abdominal pubescence appears somewhat more extensivè, though in both species this is hard to define and is only visible from certain directions. The antennal proportions are identical in the three specimens under examination.

MICRODON PICTIPENNIS (Macq.).

Aphritis pictipennis Macquart, 1850, p. 129, Pl. 12, fig. 12.

The identity of Macquart's species is unfortunately uncertain. Hardy (1921, p. 15) identified as this species, one that is evidently *M. brachycerus* Knab and Malloch, and which does not agree with Macquart's description. These latter authors state that the species appears to be related to *M. pictipennis*, but on account of the differences regard the species as distinct.

Macquart described the female and added a description of a specimen which he regarded evidently with some doubt as the male. The descriptions of the two sexes appear so different that I have no doubt that they represent two distinct species. That of the male is certainly much closer to *M. brachycerus* than the description of the female. As Knab and Malloch point out, there is nothing to indicate which sex was figured by Macquart.

The description of the female indicates a blue species similar to *M. nicholsoni* or *M. chalybeus*; there are, however, differences between the description and each of these species and it would be rash to affirm the identity of either with Macquart's type. Unfortunately the third joint of the antennae was missing when described, but the two basal joints being testaceous, at least suggests that Macquart's species was different from either species.

Hab.—Tasmania: This locality even must be viewed with doubt, as many species described as from Tasmania in this portion of Macquart's work are now known to be from the mainland.

Addendum (30th April, 1926).—The following species, which has lately been received, is of some importance as showing a further link between *M. variegatus* Walk. and the rest of the genus. When first examined it was considered a somewhat aberrant form of *M. variegatus*, but an examination of the puparium shows very distinct differences.

MICRODON PRAETERMISSUS, n. sp.

Allied to *M. variegatus* Walker but abdomen not constricted at base and puparium not reticulate. Head black, front broad, minutely granulate, except in mid line, mostly clothed with short black hairs, but some golden pubescence present on each side anteriorly and at vertex; face broader than front, somewhat flattened, retreating to oral margin, clothed with creamy pubescence, somewhat irregularly arranged. Antennae elongate, first joint blackish, cylindrical; second dark brown, very short; third brown, elongate spindle shaped, obtusely pointed, with a longitudinal sulcus along under surface, the arista appearing to arise also from the underside, in reality probably the outer side of the joint, relative length of joints 11:2:19.

Thorax black, minutely granulate, with a narrow transverse band of golden hairs across thorax at level of transverse suture, and continued down pleura as a creamy band; a few golden hairs on posterolateral angles. Scutellum black, with some golden hairs at base, apex rounded, not dentate.

Abdomen elongate, not constricted at second segment, the following segments but little widened, dark brown almost black, the second segment largely yellow, and extreme base of third yellow, the apicolateral angles of third and fourth segments and the apex of fifth yellowish-brown, pubescence dark, a patch of golden pubescence on each posterolateral angle of the third and fourth segments. Legs reddish-yellow, the coxae, trochanters and basal third of femora black. Wings rather heavily suffused along the veins.

Length, 8 mm.

Hab.—South Australia: Mt. Lofty (A. M. Lea). Type in South Australian Museum.

Described from a single somewhat damaged female, gummed to a card on which are also gummed an empty puparium and an unhatched larva.

The puparium (6 × 3·5 mm.) is of the usual shape, elliptical-ovate, flattened beneath, yellow-brown in colour; the dorsal longitudinal furrow is hardly indicated and the surface is not reticulate but dotted with numerous very small white granules resembling grains of sand; the posterior spiracular horn is broken off the empty puparium, but on the larva the horn is reddish-brown, slightly rugose, with the apex not bifid. The larva closely resembles the pupa except that the anterior horns are absent.

With the wings folded in repose it is very difficult to distinguish this species from *M. variegatus* except by the somewhat shorter antenna, though specimens of *M. variegatus* occur with unusually short third joint, the shape of this joint is somewhat different.

The specimen was received after the key was in print and could not be included. As the key now stands it would run to the section containing *M. modestus* from which it would be separated by the scutellum being dark but not sulcate. The species is, however, much more closely allied to *M. variegatus* and the key will require modification in the beginning. I am unwilling to alter it now as it is highly probable that other species await discovery and a new key to the genus will be required.

EXPLANATION OF PLATE XIV.

Fig. 1. *Microdon alcicornis*, n. sp. Head (one antenna only is shown).

Fig. 2. *Microdon variegatus* Walk. Dorsal view.

Fig. 3. *M. variegatus* Walk. Larvae and pupae.

Figs. 4-7. *M. variegatus* Walk. Lateral view showing wasp-like attitudes assumed in walking.

FURTHER NOTES ON SPECIES OF *PTEROSTYLIS*.

By Rev. H. M. R. Rupp.
(Communicated by Mr. E. Cheel.)

[Read 26th May, 1926.]

Since the publication of my Notes on Species of *Pterostylis* in September, 1925 (These Proc., 1925, 299), I have received much useful information from observers in several States, who have also sent me specimens and photographs. I, therefore, think it desirable to add some corrections and additional Notes to the former paper. In order to avoid confusion, I shall use the same numbers as were attached to the various species in the first Notes; and species not alluded to previously will be found introduced by additional numbers in brackets.

1. *P. ophioglossa* R. Br.—Mr. W. H. Nicholls, of West Footscray, Victoria, informs me that this species has never been recorded in that State. Miss H. Geissmann has sent a fine photographic study of specimens from Tambourine Mountain, Queensland.

2. *P. concinna* R. Br.—Additional locality: Paterson, N.S.W., July, 1925 (A. Rupp).

3. *P. curta* R. Br.—Miss Geissmann sent specimens of the small form alluded to as "Swallow-tail" in the first Notes. They are even smaller than I supposed, and are probably distinct from the other small form referred to. The structure of the flower, however, appears to me to justify its inclusion under this species.

4. *P. acuminata* R. Br.—I have had a very interesting correspondence with three Victorian orchid enthusiasts—Messrs. W. H. Nicholls and A. J. Tadgell, and Mrs. J. G. Coleman—with regard to Victorian forms of this species. Mr. Nicholls sent excellent photographs, and Mr. Tadgell a specimen from Mordialloc. In a valuable article on "The Propagation of our Pterostyles" (*Victorian Naturalist*, Dec., 1925), Mr. Nicholls alludes to the difference in flowering-time between northern and southern forms. I think it is even more marked than he states; and judging from my correspondence with Miss Geissmann, and specimens sent by her from Moreton Bay, the Queensland time agrees with that in New South Wales—April to early July. It is, therefore, distinctively an autumn flower in the north, just lingering into winter. It seems remarkable, then, that in Victoria it should be a spring flower, extending even to December. In view of the comparatively small difference in season, as between northern and southern States, in the case of other species (e.g. *P. curta*, *P. nutans*, *P. obtusa*, etc.), this marked divergence suggests the need of caution in identifying these forms. Mr. Tadgell's Mordialloc specimen adds force to this suggestion. It differs from all my New South Wales and Queensland specimens in the following respects: (1) Much more robust in all its parts, the flower being half as large again; (2) the lateral sepals are shorter, thicker and blunter; (3) the stem-bracts are very prominently developed and loose, the uppermost actually embracing the base of the galea, the lowest quite leaf-like. In the northern forms the bracts on the very slender stem are small and appressed, the uppermost just reaching the base of the ovary, the

lowest not leaf-like. A photograph sent by Mr. Nicholls agrees well with Mr. Tadgell's plant. Mrs. Coleman, after receiving a northern specimen, concurs with my view that the differences are so marked as to deserve further attention.

5. *P. Baptistii* R. Br.—Miss Geissmann sent living specimens in September, 1925, which fully confirmed my remarks as to the identity of this Queensland form with the typical New South Wales plant. Professor Harrison, of Sydney University, informs me that he obtained this species on Barrington Tops. Its occurrence at an elevation of over 5,000 feet is very interesting and unusual.

6. *P. falcata* Rogers.—Mr. Nicholls has sent me Victorian specimens (Dandenong Ranges) agreeing precisely with those from Mount Barrow, Tasmania.

[33.] *P. alpina* Rogers.—I have received Victorian specimens of this species from Mr. Nicholls (Athlone) and Mrs. Coleman (Fern Tree Gully). The Ven. Archdeacon Atkinson, of Penguin, Tasmania, has sent specimens from Noall Plain in that State, which seem to be identical. Smaller forms sent by the same observer from Mount Bischoff are doubtful, and may perhaps be referred to *P. cucullata* R. Br.

11. *P. pedunculata* R. Br.—Mr. Nicholls informs me that the slender, dark-flowered form referred to in the first Notes extends to Victoria.

[34.] *P. pedoglossa* Fitzg.—Archdeacon Atkinson sent beautiful specimens of this dainty orchid, which I have never collected, from Eaglehawk Neck, Tasmania; and Mr. Nicholls a plant from Cheltenham, Victoria.

14. *P. alata* Reichb. f.—Mrs. Coleman has sent a specimen from Cheltenham, Victoria, and Mr. Nicholls photographs of the robust and the slender Victorian forms. The former must be very near *P. reflexa* R. Br.

15. *P. striata* Fitzg.—Professor Ewart and Mr. Sharman identify this with *P. alata*. I venture to think that my Nandewar specimens are quite distinct from the latter, but I am still unprepared to assert definitely their identity with Fitzgerald's species.

17. *P. decurva* Rogers.—In the figure accompanying the first Notes, the galea extends too far horizontally. Mr. Nicholls has sent me further Victorian specimens. With regard to Dr. Rogers's opinion recorded at the conclusion of my former Note on this species, I agree that Miss Geissmann's small Tambourine plant is not *P. decurva*. I am inclined to think it is an undescribed species, but hope to obtain further material for examination. In January, 1926, Mr. C. Barrett paid a visit to Barrington Tops, and brought me two specimens of a *Pterostylis* which he reported to be in great abundance there. It appeared to me to be *P. decurva*; but Mr. Nicholls, who also received specimens from Mr. Barrett, points out that the labellum is densely "furred" with fine setae, whereas that of the typical *P. decurva* is glabrous. Further material is desirable for fuller investigation.

19. *P. reflexa* R. Br.—In the first Notes I commented on the variations in my herbarium specimens. Correspondence with Mr. Nicholls, and beautiful photographs forwarded by him, have satisfied me that the forms with very long pointed sepals, and a less "swollen" flower, must be regarded as [35] *P. revoluta* R. Br.

20. *P. truncata* Fitzg.—Mr. Nicholls sent a most charming photograph of a colony of this quaint species, growing on the You Yangs Range between Melbourne and Geelong, where he discovered it a year or so previously.

21. *P. grandiflora* R. Br.—I was unaware that this species extended to Victoria, but Mr. Nicholls sent a photograph, and Mrs. Coleman states that it is well known, though not abundant. The "hood" in our northern form seems to be larger, broader and more flattened, and apparently darker in colour. I have received specimens from Miss Geissmann at Tambourine Mountain.

22. *P. parviflora* R. Br.—It is extremely difficult to settle satisfactorily the problem of recognizing a specific or even a varietal distinction between this and Lindley's *P. aphylla*. In November, 1925, Archdeacon Atkinson sent me living specimens of what he regarded as Lindley's plant, from the highlands between Cradle Mountain and the N.W. Tasmanian coast. The typical *P. parviflora* abounds in Tasmania in the autumn, corresponding with the mainland form; a slender plant with or without a basal rosette at flowering-time. But this late spring plant of the highlands is a stunted, robust succulent form like *P. cycnocephala*, with no rosette, growing in peat. At the same time, neither Mr. Nicholls nor I can detect any difference in the flower from that of the typical *P. parviflora*.

[36.] *P. pusilla* Rogers.—Mr. Nicholls kindly sent a specimen of this little plant, which up to the present is only recorded from Victoria and S. Australia. It is described by Dr. Rogers (*Trans. Roy. Soc. S. Aust.*, xlii, 1918).

[37.] *P. Suttonii* Ewart (?).—Archdeacon Atkinson sent this species, which I had not previously heard of, from Hadfield Plain, Tasmania. It is allied to *P. cycnocephala* and *P. mutica*, but has no rosette.

26. *P. mutica* R. Br.—In September, 1925, I found in abundance near Paterson, N.S.W., a remarkably large form of this species. Quite a number of plants exceeded a foot in height, and one bore 14 flowers. Mr. Nicholls sent me specimens of the two Victorian forms, one characteristically slender, the other stout and robust.

In addition to the species recorded above which were not mentioned in the first Notes, I have received from Mr. A. J. Tadgell a specimen of the rare Victorian *P. Toveyana* Ewart and Sharman. I have not included it in the above list, because I am uncertain from my correspondence whether it is regarded as a good species, or a hybrid *P. concinna* × *P. alata*, or both. It shares with the former and *P. ophioglossa* the distinction of a forked labellum, but the fork is very small. Archdeacon Atkinson has informed Mr. Nicholls that he believes it to be not uncommon on Flinders Island. If it is a good species, as I suppose, it brings the number of species I have reviewed in these and the former Notes to thirty-eight.

AN EXPERIMENTAL STUDY OF THE DEVELOPMENT OF THE LIMBS OF THE CHICK.

By P. D. F. MURRAY,*
Linnean Macleay Fellow of the Society in Zoology.

(Fifty-three Text-figures.)

[Read 26th May, 1926.]

The objects of this work were to reinvestigate and extend the results announced in a brief note published in 1925 (Murray and Huxley, 1925*a*). In this paper it was concluded that isolated fragments of the limb buds of the four-day chick are able to self-differentiate when living as grafts on the chorio-allantoic membrane of older chicks; that the bud of the four-day chick is a mosaic; it was hinted that each of the morphological regions of the limb (femur, tibio-fibula, etc.) is represented by a single piece of the mosaic; that no regeneration or regulation occurs in fragments of the bud, except that it was concluded that if a grafted fragment contains only part of a piece of the mosaic, that part could so regulate its future development as to form the complete morphological region of which it was originally a part, so that a fragment of the bud which contains part only of the region which would normally form femur will, when growing as a graft, form a complete femur. It will be seen that the results of the present work uphold and confirm the tentative conclusions previously advanced, except in regard to the last point (regulation). A considerable amount of further information has also been obtained bearing on the factors concerned in the development of the form of bones and joints.

Technique.

The technique does not differ in essentials from that used by Professor Julian Huxley and the present author in previous works (Huxley and Murray, 1924, and Murray and Huxley, 1925*a* and *b*), and by Minoura, Hoadley, Willier, Murphy, Danchakoff, etc. Nevertheless a few improvements have been made which may be worth mentioning.

Briefly, the method consists in removing the limb bud, or the region which it is desired to graft, from a chick of a suitable age. In the present experiments the chicks used as "donors" (of grafts) have been of the ages of two, three, four and five days' incubation. When the graft has been removed from the "donor", a host egg is taken, nearly always of eight days' incubation, and the graft is placed upon its chorio-allantoic membrane.

(1) Preparation for grafting buds of four- or five-day chicks.

The egg is removed from the incubator and its upper surface washed with 90% alcohol, in order to sterilize the surface. It is perhaps questionable whether this has much real effect, but it probably helps. Next, the shell is slightly cracked by light blows with such an instrument as a pair of forceps, and the shell over

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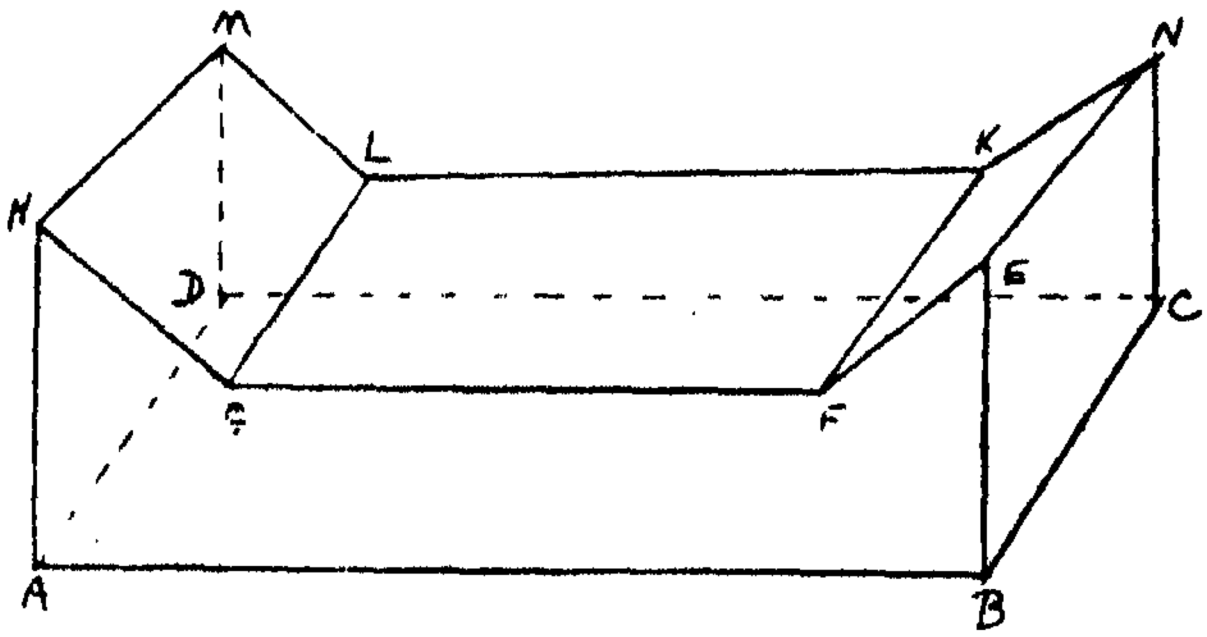
* This paper has been submitted as a thesis for the degree of Doctor of Science in the University of Sydney.

the upper surface is gently picked away, leaving the shell membrane intact if possible. Next, the egg is moved into a sterile shelter consisting of a large accumulator jar lying on its side, and previously sterilized by flaming. This is, of course, to guard against air-borne infection. Next, the shell membrane is lightly torn with forceps, so as to expose the embryo. The embryo is then removed from the shell with scissors and forceps and placed upon a flat sheet of glass, which must have been carefully washed, as otherwise grease prevents the salt solution, into which the embryo is placed, from spreading properly. The egg is discarded. The embryo is cleared of adherent yolk, etc., and enough of the blastoderm, amnion, etc., is cleared away to enable the limb buds to be seen clearly. The two limb buds of one side are now cut away by means of knives made of the triangular halves of Gillette safety razor blades, which have been broken in two along a diagonal. These knives are held in artery forceps. When the two buds have been removed, the donor chick, still retaining the two buds of the opposite side, is handed over to the assistant and fixed as soon as possible. If it be desired for the experiment, the buds are now cut into fragments by means of the razor-blade knives. The preparation of the grafts is now complete.

Chicks of two or three days' incubation.

The procedure is the same as for four- or five-day chicks, except that the much smaller size of the embryo makes it necessary to use a binocular microscope in dissecting it. To do this, it is of course necessary to take the embryo out of the sterile shelter, which would involve a serious increase in the risk of infection were not some precaution taken. I have used, therefore, a small portable glass shelter, consisting of a floor formed by a plate of glass, half-plate size, A B C D in the annexed diagram, two walls of wood of the shape indicated by A B E F G H, and a roof formed of a piece of glass (G F K L) and two sloping glass wings (H G L M, E N K F).



The embryo is placed upon its small piece of glass and then transferred, still on the glass, to the floor of this shelter, which is then placed upon the stage of the binocular. The raised lateral wings allow dissection to be carried on beneath the shelter. When this is complete, the embryo is replaced in the main shelter for the grafts to be made.

(2) Grafting.

Previous to the inception of the operation, the eight-day chicks, upon which it is intended to make the graft, are "candled" and the embryo located. Near the black spot which reveals the embryo, a mark is made on the shell. At this position

a rectangular cut is made in the shell with a scalpel whose blade has been made into a saw by means of a file. Care must be taken that the cut be not so deep as to pierce the shell-membrane, as otherwise the chorio-allantoic membrane may be damaged. This will result in bleeding, and this usually in death, probably from infection. Previous to sawing, the shell surface is sterilized with 90% alcohol. It has been my practice to complete the sawing of all the hosts before the operation actually begins. In grafting, the egg is placed upon an egg-rest made of cotton-wool in a small petrie dish, the rectangle of shell is removed, the shell membrane is torn back by means of a needle with its point bent over to form a hook, and the graft, carried on the point of a needle or razor-blade knife, is gently slipped through the hole and laid to rest on the chorio-allantoic membrane which is immediately beneath the aperture. In grafting fragments of two-day chicks I find it easier to inject the graft into the egg with a pipette. It should be emphasized that, in my experience, the smaller the hole in the shell membrane, the greater the chance of success. Large holes, in my experience, lead to heavy mortality.

(3) Sealing the host egg.

When a graft has been made, the host egg is handed to the assistant, who works in another sterile accumulator jar shelter. She (my wife has acted as my assistant throughout) replaces the torn edge of shell-membrane in as nearly normal a position as possible, lays over this another piece of shell-membrane taken from another egg (which may be a fresh egg or one from which a donor has been taken), over this again replaces the piece of shell which has been removed in order to make the graft, and then covers this with another piece of shell-membrane from another egg to keep it in position. The advantages of using shell-membrane for sealing the eggs are two. Firstly it is sure to be sterile; secondly, its shape is rounded and so conforms fairly easily to that of the host egg. Finally, after the operation is over for the day, the sticking down of the shell-membrane on the host eggs is ensured by painting the edges with a mixture of vaseline, paraffin wax, and a little lysol.

(4) Recovery of the grafts.

Nine days after the operation, the host eggs are opened and the grafts, now in many cases grown to a surprisingly large size, removed. They are fixed in Carnoy's fixative and then stained for a week in methylene blue, after which they are cleared by the Spalterholz method in benzol benzoate and oil of wintergreen. Only a few specimens were treated by other methods, a few being stained in borax carmine and a few cleared in cedar oil. A number were sectioned and stained in Ehrlich's Haematoxylin and Eosin.

The process of "Taking" of the graft.

This I have not studied. According to Danchakoff (1918), who studied the process when grafting fragments of spleen, the graft tissues, lying on the membrane, rupture the very delicate ectodermal epithelium of the latter, and by their weight tend to sink into a fold of the membrane. Thus they are brought into close relation with the mesodermal tissues of the membrane, whence they are invaded by mesenchyme cells and blood-vessels. At eight days the blood-vessels of the chorio-allantois are still developing. While there is already a vigorous blood circulation, the complicated network which later appears is still in process of development.

DESCRIPTIVE.*

No. 1. Figs. 1*a*, 1*b*.

Origin.—This specimen developed from a graft of an entire right hind limb bud of a four-day chick. The homologous bud from the opposite side of the same donor embryo is shown in Fig. 1*b*. It will be seen that the base of the bud is still longer than the axis of the limb, while sections show that it consists internally of a mass of mesenchyme with no sign whatever of any axial condensation.

Graft.—The graft consists of a pelvis, femur, tibio-fibula, at least one tarsal, four metatarsals (of which two and three at least are fused together, while one and four may still be separate), and four toes. The pelvis consists of the three normal elements, ilium, ischium, pubis, but the posterior twisting of the pubis and ischium has not occurred. In shape the pubis and ischium show a surprisingly close approach to the normal, while the ilium is apparently incomplete. The femur has a head and a trochanter, and at the distal end has attempted, with a fair measure of success, to form condyles. The tibia is a large and stout cartilage articulating with the femur, while the fibula is much thinner and is not only as long as the tibia, but, being bent, must actually be longer. In the tarsal region only one tarsal element is visible. This, however, does not necessarily mean that only one free tarsal is present. The staining of the specimen is not very good, and other small cartilages may well have been overlooked in this region. On the other hand, the remaining tarsal elements may have fused with the tibia, to form the tibio-tarsus, or with the metatarsus to form the tarso-metatarsus. There are four toes, the first and second having only one phalanx, the third three, and the fourth two. It should be noticed that digits 3 and 4, although having less than the normal number of phalanges, have well formed terminal phalanges. No bone is detectable, but the specimen has not been sectioned. A number of feather germs developed in this graft.

No. 2. Figs. 2*a*, 2*b*.

Origin.—Entire right posterior bud of four-day chick (Fig. 2*b*). The bud is in a considerably earlier stage than that shown in Fig. 1*b*, having a base much longer than the axis of the limb. It is indeed one of the least developed buds I have encountered on a four-day chick. In section it shows merely a mass of loose mesenchyme, with, of course, an ectoderm covering.

Graft (Fig. 2*a*).—The graft is a very abnormal structure, a fact which I think is probably due, not to lack of "potency", but to the abnormal conditions. It is naturally more difficult for a graft to develop normally when it originates from a bud which has attained to so slight a differentiation as this one. The looseness of the mesenchyme of which it was composed would alone tend to allow disintegration of the graft tissues by the invading cells of the host until they were so isolated from one another as to be unable to act together as a concerted whole, while this same process would also be furthered by the relatively great length of cut surface. This argument is supported by the graft shown in Fig. 46*a*, which came from part of a bud of a three-day chick.

In spite of these disabilities, however, the graft has developed into a large structure which obviously represents an attempt to form an entire limb. At what corresponds to the proximal end of the limb, there are two bars of cartilage

* Magnifications of figures are approximate only. In most cases a figure has been given of the bud which is fellow to that used as a graft, on the opposite side of the same embryo.

representing the pelvis, or part of it. From their general form they would appear to be the pubis and the ischium (the ilium should be broader). The greater part of the graft consists of a single long bent cartilage, the distal end of which is

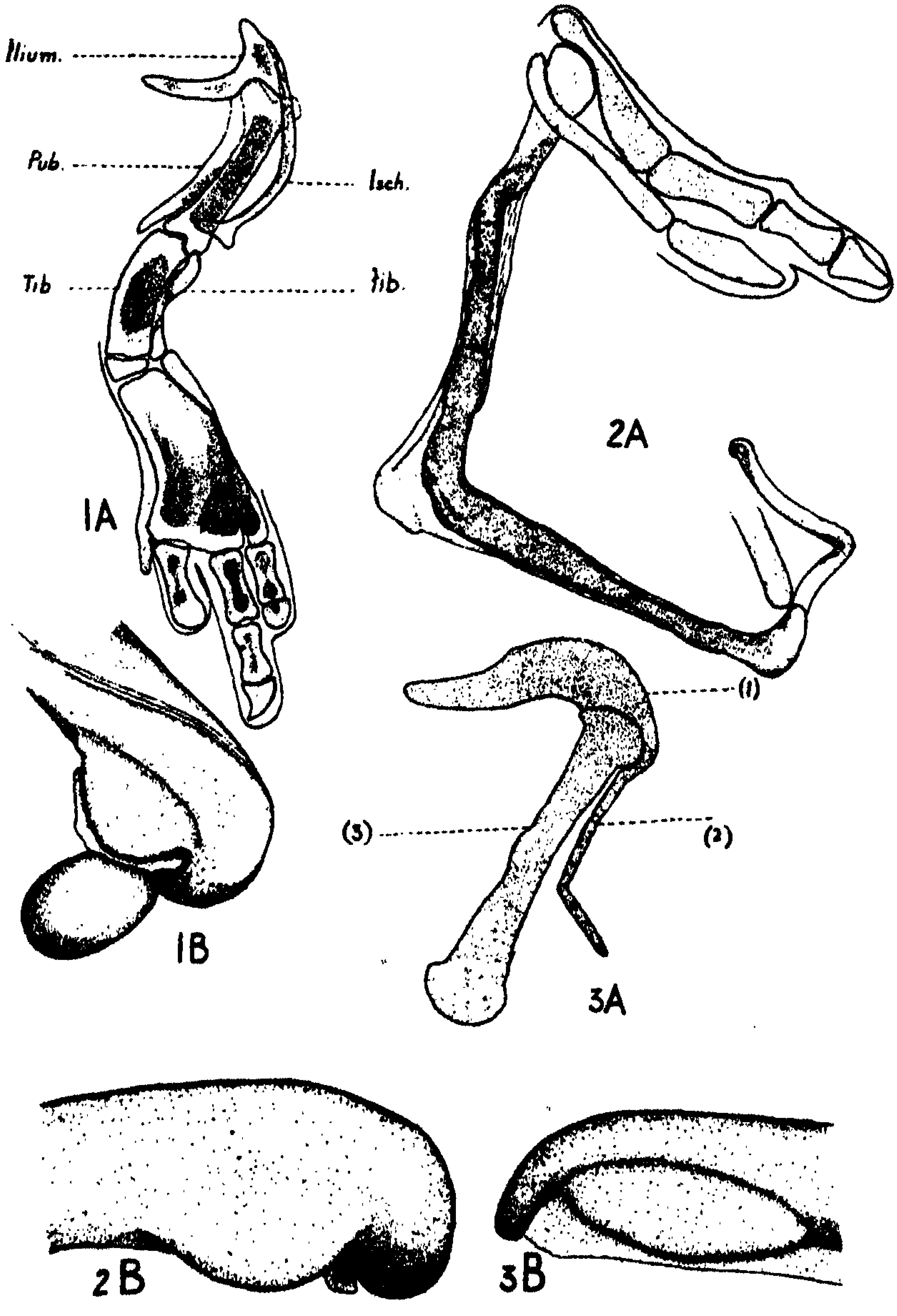


Fig. 1.—*a.* No. 1. *Fib*, fibula; *Isch*, ischium; *Pub*, pubis; *Tib*, tibia. *b.* Fellow to donor of No. 1.
Fig. 2.—*a.* No. 2. *b.* Fellow to donor of No. 2.
Fig. 3.—*a.* Basal portion of No. 3; explanation in text. *b.* Fellow of donor to No. 3. × 6.

followed by two obvious metatarsals and toes. There is evidence indicating that this long cartilage is really the femoral region and the tibio-fibular region which have not separated from one another. In the first place, some ossification has occurred in each arm of the bent structure, and in each case about the middle of the arm. The bone of a normal skeletal element of the extremities begins to form first round the central region of the element (Fell, 1925). Secondly, the cartilage, or at any rate the more deeply stained region thereof, shows a slight constriction at the point where the bend occurs, and thirdly there appears (though this is by no means certain) to be a small, more or less, discrete piece of cartilage on the convex side of the bend, in the position which would normally be occupied by the patella, if this bend were in the position of the knee-joint. Lying distal to the bent cartilage are two toe-like structures, each consisting of a longer basal cartilage suggestive of a metatarsus, while one of these has, lying distal to it, a toe consisting of three phalanges, and the other a toe of one phalanx. As regards joint structures, the proximal end of the femoral region has a lateral projection more or less suggestive of a head, while the joints between the phalanges of the toes appear fairly normal. Otherwise there is no joint structure present. That between the femoral and tibio-fibular regions has not developed at all, on account of the failure of these two regions to separate.

No. 3. Figs. *3a*, *3b*.

Origin (Fig. *3b*).—This specimen developed from a bud of similar age, form and structure to the last. It is, therefore, not necessary to describe it. The figure will suffice.

Graft (Fig. *3a*).—The graft in removal from the host egg was damaged, and exists now in two pieces. One piece is shown in Fig. *3a*, the remainder has been cut in T.S. The portion shown in Fig. *3a* is difficult to interpret with any certainty, but appears to be a distal portion of a femur with complete tibio-fibula attached. The condyles have not developed normally. On the other hand it is possible to interpret the cartilages marked (1) and (2) in Fig. *3a*, as pelvic elements, and (3) as a femur. The other portion of the graft, in sections, lay distal to region (3) of Fig. *3a*, i.e. beneath it in the figure, and is a very abnormal and complicated structure, in no way resembling anything normal, except that the number of rods of cartilage concerned is greater than in the more proximal region, as should be the case in a region representing a foot. It seems that here again we have an attempt to form a nearly whole limb, the proximal region of the femur being absent, probably through the basal part of the bud being left attached to the donor and so only part of the femoral region being included in the graft.

No. 4. Fig. 4.

Origin.—The entire anterior bud, of side unknown, from a donor probably four days old, but perhaps five days. The bud was considerably damaged when the graft was made.

Graft (Fig. 4).—The graft consists merely of a small, irregular shaped nodule of cartilage which is in no way suggestive of an entire wing. Its failure to develop more satisfactorily is probably not due to "impotency", but to some hostile condition of grafting environment, or more probably to its damaged condition when the graft was made. We shall see later that portions of wing buds of four-day chicks may produce structures which are nearly whole limbs.

No. 5. Figs. 5*a*, 5*b*.

Origin (Fig. 5*b*).—The entire right posterior bud of a donor four days old.

Graft (Fig. 5*a*).—This structure has been figured for two reasons: Firstly, it is a good example of the development of bone predominantly on the concave side of a bent element, and secondly, because it is a good example of the more

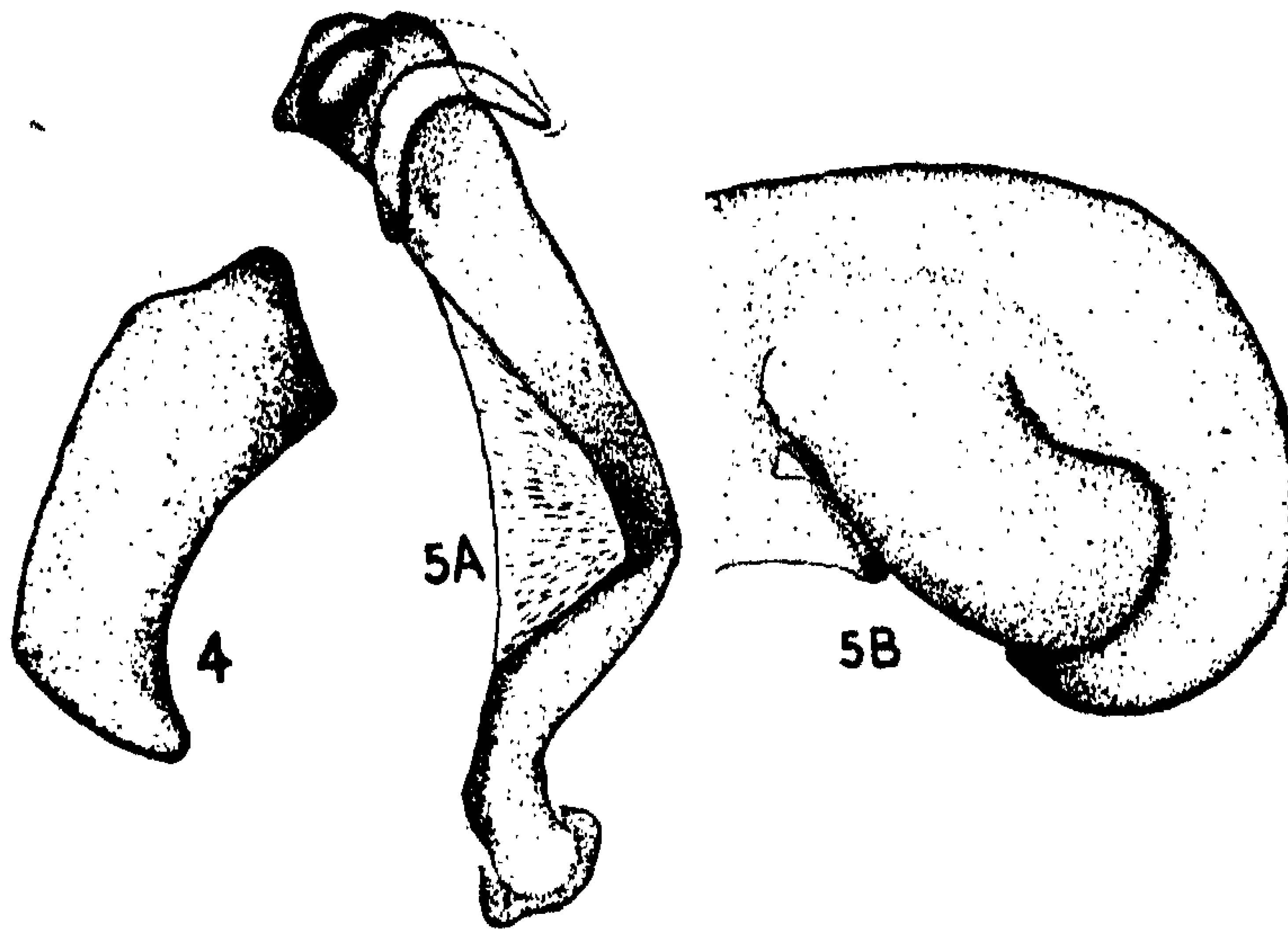


Fig. 4.—No. 4.
Fig. 5.—*a*. No. 5. *b*. Fellow of donor to No. 5. × 7.

hopelessly abnormal kind of structure which one occasionally meets in these grafts. Coming from a whole limb bud it is inexplicable, i.e. it cannot be interpreted by any stretch of imagination as an entire limb. The reason for the development of a structure of this kind may lie in damage to the bud in removing it from the donor, or in unfavourable conditions of grafting.

No. 6. Figs. 6*a*, *b*, *c*.

Origin (Fig. 6*c*).—The basal half of the hind bud of a four-day donor. The fellow bud to the donor, when figured, had been separated from the chick, and consequently it cannot be said for certain that the entire bud is figured. Part of the basal region may be missing. Nevertheless, it is probable that the bud as figured is complete or nearly so. This same cause prevents us from saying from which side the bud came—right or left of the donor.

Graft (Figs. 6*a*, 6*b*).—The graft consists of a complete femur and parts of a pelvis. The latter have not been analysed. The femur is a very well formed structure, having a good head and trochanter, and condyles (Fig. 6*b*). The existence of a patella is improbable, though something of the sort seems to be detectable, lying between the condyles. This seems from sections, however, to be fused with the distal end of the femur and consequently to be part of it. Ossification is advanced, practically the whole femur except the extremities being surrounded by bone. Displacement of the cartilage has begun in the central region. This has not been shown in the figure.

No. 7. **Fig.** 6*d*.

Origin (Fig. 6*c*).—The apical half of the same bud as No. 6.

Graft (Fig. 6*d*).—An incomplete tibio-fibula, and a foot, the completeness of which is probable, but doubtful. That the tibia is incomplete is shown by its tapering form and the curious hook-like proximal end. The fibula is a thin rod, also tapering proximally, and swelling distally. The foot consists of at least

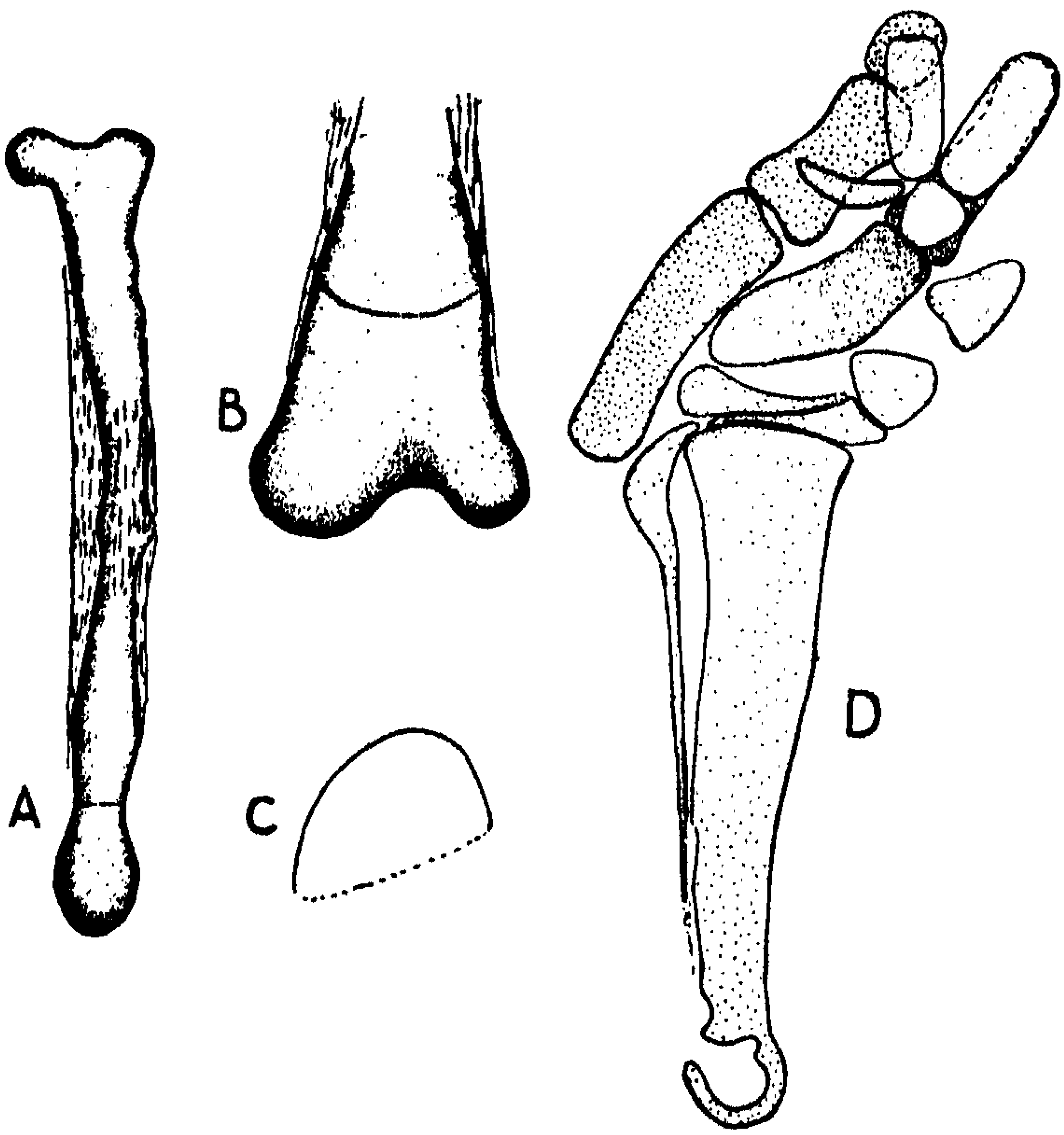


Fig. 6.—*a*. No. 6. × 5. *b*. Condyles of No. 6. × 7. *c*. Fellow of donors to Nos. 6 and 7. *d*. No. 7. × 6.

three toes, two turned back upon themselves, so that in the figure the distal phalanges lie above the proximal, pointing back towards the tibio-fibula. The smallest toe, on the right, is probably drawn incompletely, as damage has been inflicted in dissection in this region, and one phalanx perhaps destroyed. The same damage extended to the right of this toe, and it is probable, or at least quite possible, that another small toe (which would then be No. 1) has been destroyed here. There has been no fusion of the metacarpals. Two tarsals are present, discrete from other cartilages.

No. 8. Figs. 7*a*, 7*b*.

Origin (Fig. 7*b*).—Basal half, right posterior bud, 4-day donor. The bud is still markedly wider at the base than it is long from base to apex.

Graft (Fig. 7*a*).—The graft is a very imperfect structure, consisting of three long rods of cartilage, meeting all in one place, and perhaps fusing there. At the point of junction of the three rods there is a small piece of cartilage marked with an asterisk. The poor differentiation of form in this graft renders it impossible to draw homologies between its parts and those of the normal limb with certainty; nevertheless, one is struck by the fact that the graft consists of three rods of cartilage meeting, just as do the femur, tibia and fibula of a normal limb. Probably, then, these three rods represent the three elements named, in which case the smaller piece of cartilage marked with an asterisk would appear to be the patella. As to which of these rods represents femur, which tibia, and which fibula, it would be very rash indeed to hazard a guess, though perhaps that on the right, with its more expanded base, is more suggestive of a femur than are either of the two others.

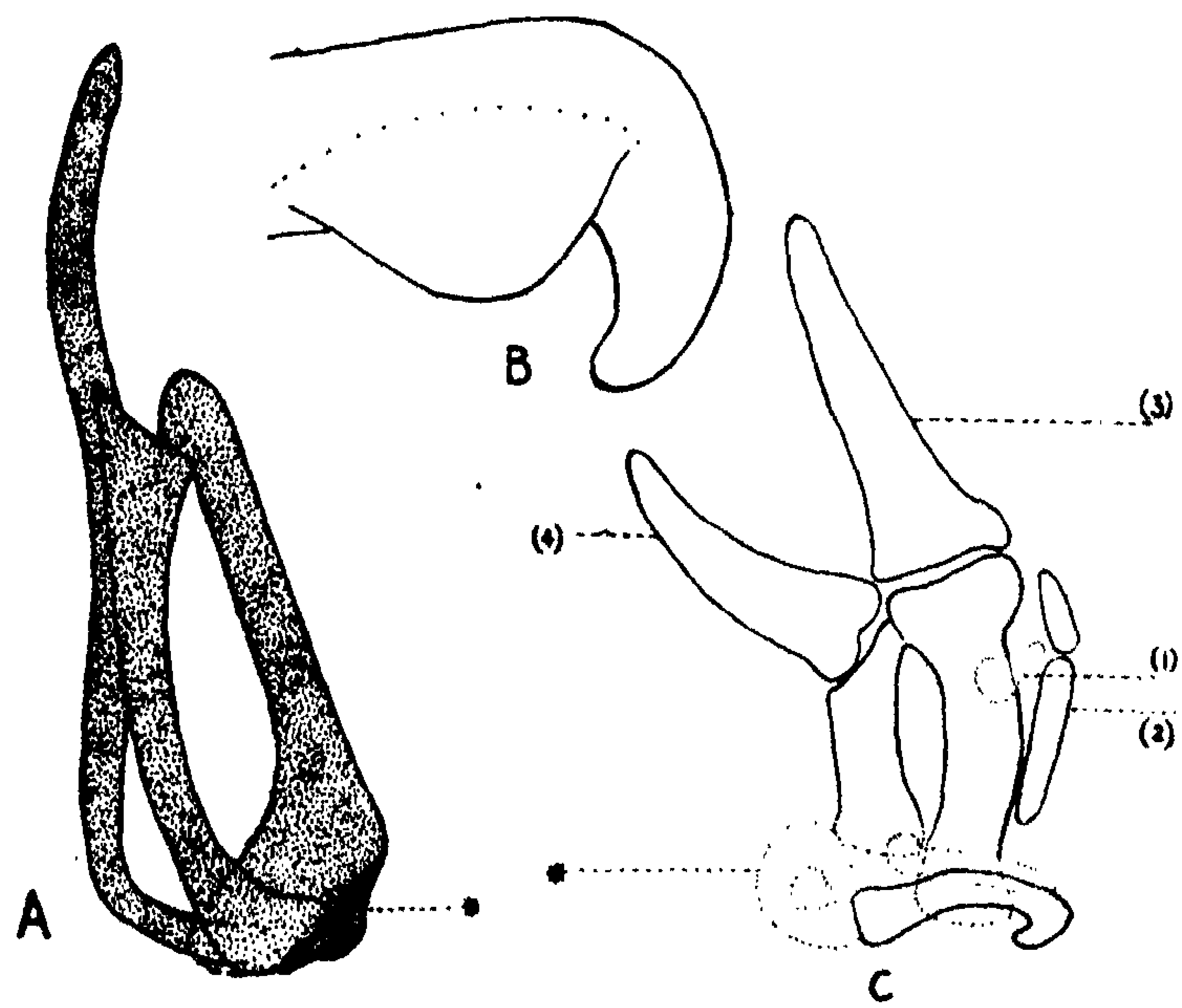


Fig. 7.—*a*. No. 8; explanation in text. × 7. *b*. Fellow of donor to Nos. 8 and 9. × 6. *c*. No. 9. Figures indicate serial numbers of digits. Asterisk explained in text. × 5.

No. 9. Figs. 7*b*, 7*c*.

Origin (Fig. 7*b*).—From the apical half of the same bud as No. 8.

Graft (Fig. 7*c*).—The graft, while of a less hopelessly irregular form than No. 8, is yet far from a normal foot. Fig. 7c shows it as drawn first from the cleared specimen after methylene-blue staining, and then from horizontal sections. It is nevertheless, obviously an attempt to form a foot, having two large, and at least one, perhaps two, smaller "toes", three metatarsals, of which the two larger belong to the two larger toes and the smaller to the smallest of the three definitely known toes. The first toe is a tiny structure whose existence is doubtful. It was thought to be dimly visible in the cleared specimen, but could not be found in the sections. In this connection, however, it should be pointed out that the sections

were poor, being considerably lacerated, while so small a structure would naturally be difficult to locate in horizontal section of the whole object. In position it is ectopic. All the toes consist of but one phalanx each.

Lying proximally to the metatarsals are at least two rods of cartilage, with their long axes transverse to that of the whole foot. These may very well be tarsals, but since one of them (asterisk) curls away from the foot, it is possible that they may really be the distal ends of the tibia and fibula, the proximal ends of which are apparently to be found in No. 8.

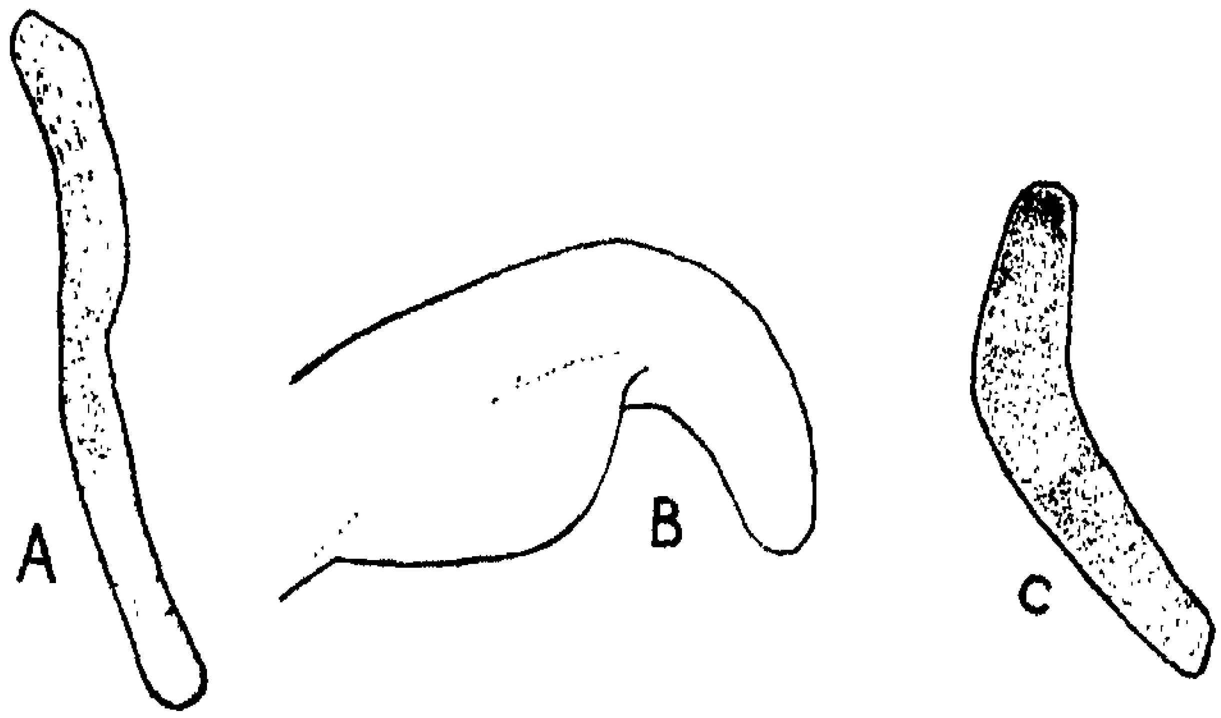


Fig. 8.—*a.* No. 10. × 7. *b.* Fellow of donors to Nos. 10 and 11. × 7. *c.* No. 11. × 7.

No. 10. Figs. *8a*, *8b*.

Origin (Fig. *8b*).—The basal half of the right posterior bud, from a four-day donor. The bud is still considerably longer in the axis of the embryo than in that of the future limb.

Graft (Fig. *8a*).—The specimen consists merely of a thin bar of cartilage with probably a little bone.

No. 11. Figs. *8b*, *8c*.

Origin (Fig. *8b*).—The apical half of the same bud as No. 10.

Graft (Fig. *8c*).—The graft is merely a curved bar of cartilage. It is interesting that these two grafts (Figs. *8a* and *8c*), both originating from the halves of the same bud, should each have taken as a graft, but should each have developed merely into a simple bar of cartilage, with no other sign of differentiation of form.

No. 12. Figs. *9a*, *9b*.

Origin (Fig. *9b*).—The basal half of the right anterior bud of a four-day donor. A fairly advanced bud, which would probably show in section, however, very little, or no axial condensation.

Graft (Fig. *9a*).—A complicated and abnormal structure, the different parts of which cannot be interpreted with certainty. There is, however, one element which has taken on its normal form to an extent sufficient to make its identification fairly certain. This is the scapula (Fig. *9a*, *Scap.*). It is a flat, almost leaf-like element, quite unlike any other. Thus I feel on fairly safe ground in identifying this element. Further identification of parts of the graft must depend on our knowledge of the fact that the graft comes from the right side of the donor chick. This being the case, and since the scapula (in the normal) lies

posterior to the humerus and other elements of the pectoral girdle, the orientation of the graft as drawn in the figure must be as follows: The scapula being nearest to us, we are looking at the posterior face of the whole structure. It is part of a right wing, and hence the outer side must be to the right, the inner to the left. In this case, the humerus (*Hum*) is the cartilage with the rounded "proximal" end tapering distally, and the large element to the left is probably the coracoid (*Cor*), while the bifurcated structure at its "distal" end must be a fragment of the sternum. The small nodule above the coracoid is then probably a tiny piece of furcula. The only other possible explanation of this structure makes what I have identified as the coracoid into the humerus, my fragment of sternum into the proximal end of the radio-ulna (which, undoubtedly, it resembles more than it does a piece of sternum), makes my humerus into the coracoid, and must either call what so much resembles a scapula, a clavicle, or else assume a complete reversal of antero-posterior polarity.

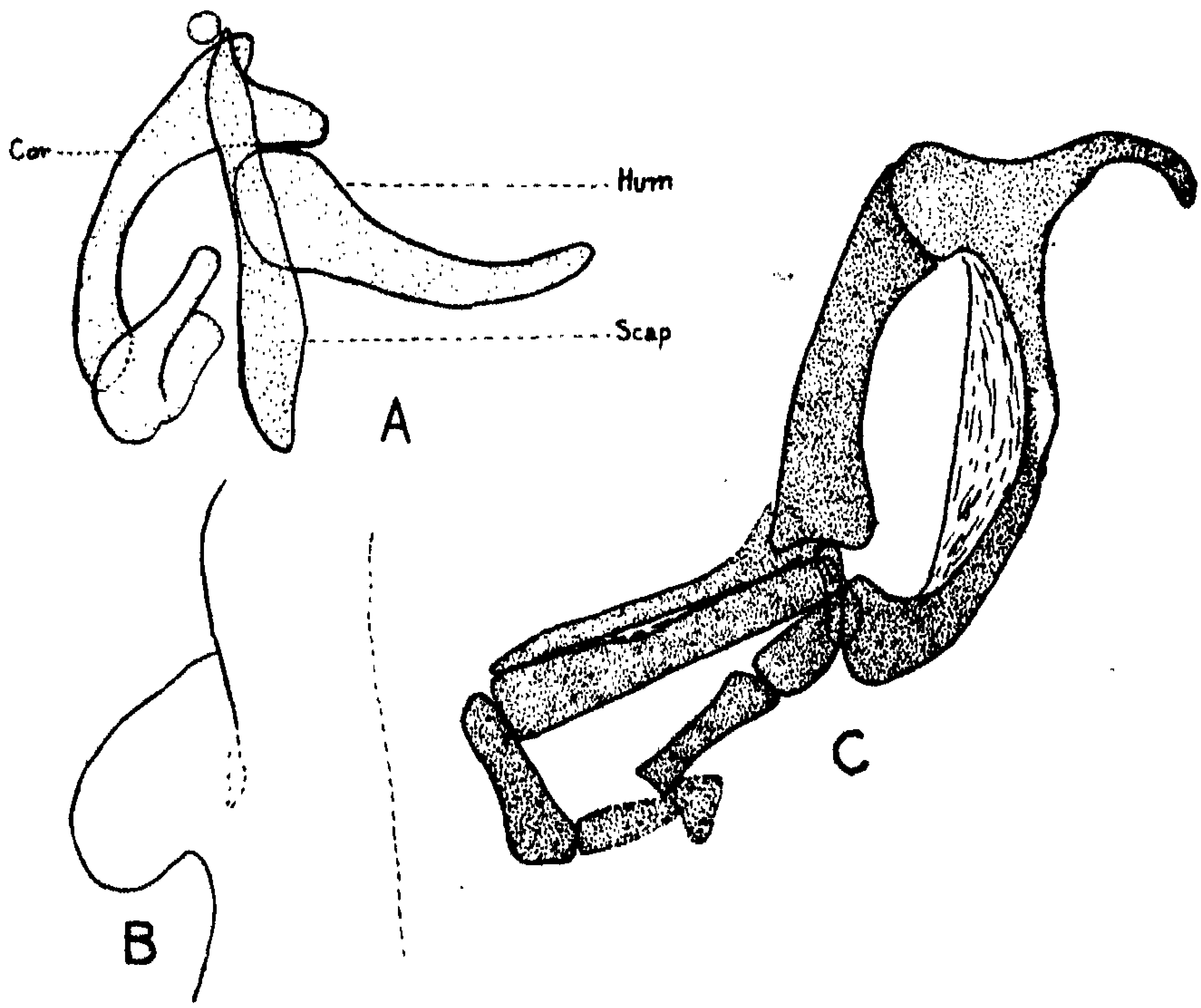


Fig. 9.—*a.* No. 12. × 9. *Cor*, probably coracoid; *Hum*, probably humerus; *Scap*, probably scapula. *b.* Fellow of donor to Nos. 12 and 13. × 7. *c.* No. 13.

No. 13. Figs. 9*b*, 9*c*.

Origin (Fig. 9*b*).—The apical half of the same bud as No. 12.

Graft (Fig. 9*c*).—The graft consists of the distal end of a humerus, radius, ulna, at least one carpal, almost certainly present as a separate element, carpometacarpus, and two digits. The humerus fragment is pointed at its proximal end, expanded distally. It passes into the radius without joint that I can discover, but is jointed with the ulna. The ulna is a stout, slightly curved bar of

cartilage, while the radius is much thinner, and is markedly curved. Notice that the ossification in the radius is much more marked on the concave than on the convex side. Beyond the radius and ulna lies the only free carpal detectable, and it is not absolutely certain that it is not partially fused with one or other of the neighbouring elements, since its boundaries are hard to see with exactitude. Next distally come the three metacarpals, two of which lie side by side, presaging a carpo-metacarpus, though they seem not to be fused at their ends. The first digit has two phalanges; the second has three phalanges; the third has no phalanx separate from the metacarpus. Sections show clearly the existence of muscles between the radius and ulna. The greater part of the other muscles has been dissected off.

No. 14. Fig. 10*a*.

Origin.—The basal half of a posterior bud of a donor four days old.

Graft (Fig. 10*a*).—The graft consists of a distal region of a femur and the proximal regions of the tibia and fibula. The femur shows, distally, fairly well

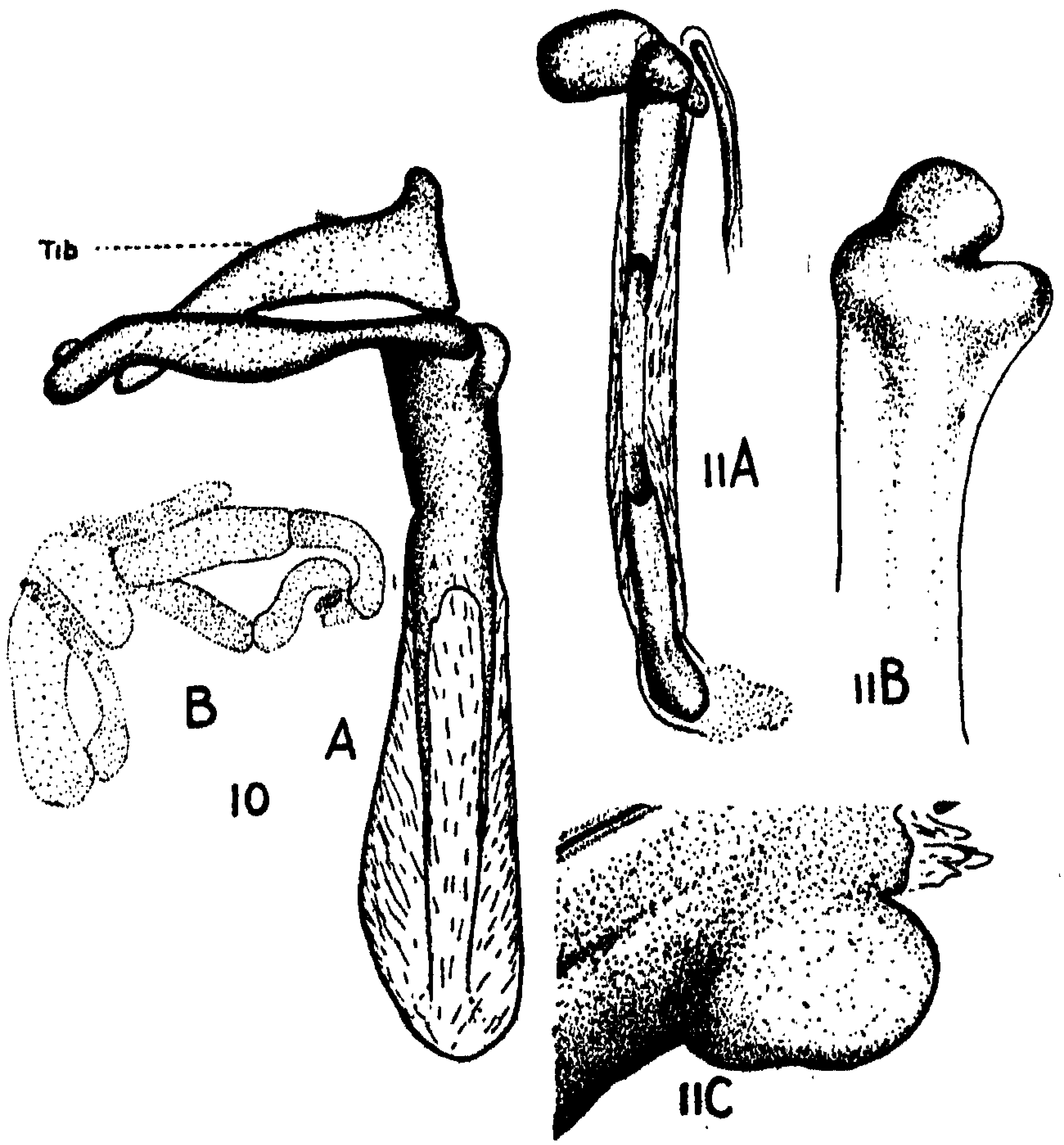


Fig. 10.—*a*. No. 14. *Tib*, tibia. *b*. No. 15.
Fig. 11.—*a*. No. 16, with the head towards the observer. *b*. No. 16, proximal end, diagrammatic. *c*. Fellow of donor to No. 16.

developed condyles. A large amount of bone has been formed, and it is important to note that this has been developed almost entirely round the proximal region of the femoral fragment, i.e., in what must correspond with the central region of the whole femur. Replacement of cartilage has also proceeded vigorously, nearly all the cartilage having disappeared in the proximal region. A patella seems to be absent. It is difficult to identify definitely the two tibio-fibular elements, but since that marked (*Tib*) is somewhat the larger of the two, it is probably the tibia. At the distal end of the fibula is a small fragment of cartilage closely applied to it, of unknown homology. It may be the patella displaced.

No. 15. Fig. 10*b*.

Origin.—The apical half of a posterior bud of a four-day donor, the same bud as No. 14.

Graft (Fig. 10*b*).—The graft consists of a rather poorly differentiated tibia, fibula, and foot. The staining is poor, but sections have been used to clarify the principal points of interest. The graft has at least three toes. These are clearly discernible in the sections, but I have not been able to find the fourth toe. The two larger toes have each a metatarsal and two phalanges, but the smallest of the three is a simple rod of cartilage without segmentation into metatarsals and phalanges. Proximal to the metatarsal region is a large rod of cartilage, beside which lies a thinner rod, in the positions shown in the figure. These are evidently the tibia and fibula. The development of the form of individual elements is poor, there being, apparently, no condyles at the base of the tibia, etc.

The figure was constructed after study of the whole cleared object and of sections.

No. 16. Figs. 11*a*, *b*, *c*.

Origin (Fig. 11*c*).—The proximal half of the right hind bud of a four-day donor. The base of the donor bud is longer than the axis of the limb. Internally, sections show the bud to consist of dense mesenchyme, but there is no trace of any preskeletal condensation.

Graft (Figs. 11*a*, 11*b*.).—The graft consists of part of a pelvis and a femur which is complete except for condyles, which do not seem to have developed. The joint structures of the proximal end, however, have developed well, as shown in Fig. 11*b*. It should be said that Fig. 11*b* is purely diagrammatic. It was very difficult to see the whole of the apical structures of the femur at the same time, owing to the presence of the pelvic elements, hence this figure had to be constructed from several sketches made from different angles, and with different methods of illumination. Nevertheless, while it may contain minor errors of form, it is correct in showing the existence of a definite head and trochanter. The distal end of the femur has not developed normally. There are no condyles, and the structure seems to end somewhat abruptly as far as the cartilage is concerned. Ossification has proceeded vigorously in the femur, the whole of the cartilage, except the ends, being invested in layers of bone, while in the central region the cartilage has disappeared altogether. Normally it would, of course, have been replaced by marrow, but whether true marrow has formed here I am not prepared to say. The cavity contains masses of red blood cells.

A pelvis is present, apparently consisting of two pieces. One piece is a thick bar lying proximally up against the head and running parallel to the femur for nearly half its length, all the time on the posterior aspect of the femur. The other piece lies mainly anteriorly and externally to the femur. Anteriorly it is

a broad sheet, probably partly ossified, in the plane at right angles to the length of the femur. Externally it curves round as a slender bar and runs down the external face of the femur, broadening out into a fan shape, for a short distance, not as far as the other piece. On the internal face it curves round just below the head of the femur and lies across the axis of the latter as a thin bar stretching probably right across the axis of the femur.

No. 17. Figs. 12*a*, 12*b*.

Origin (Fig. 12*b*).—The basal half of the right posterior bud of a four-day donor. The length of the bud is slightly greater than its width.

Graft (Fig. 12*a*).—The graft consists of a complete femur with well developed head, indications of condyles, and the proximal regions of a tibia and fibula. The trochanter is absent. Ossification has been proceeding, resulting in the whole of the femur except the ends being ensheathed in a layer of bone. Notice that the femur is bent to the right and that most bone formation has proceeded on the concave side. The cartilage in the central region has begun to be replaced. There is no pelvis present.

No. 18. Figs. 13*a*, 13*b*.

Origin (Fig. 13*b*).—The basal half of the left posterior bud of a four-day donor. The width of the bud at its base is slightly greater than its length.

Graft (Fig. 13*a*).—The graft is a complicated structure, consisting of the basal part of a femur, an ilium which must be nearly complete, a pubis, an ischium, and two anomalous cartilages, one of which is probably a rib. The figure shows the structure from the morphologically median side. The base of the ischium lies across the base of the femur, the head of the femur projects to the right of the ischium, diagonally upwards and towards the observer. The trochanter is supposed to be seen through the ilium. A considerable amount of bone has developed in the femur, and it should be noted that bone development has occurred more in the distal region of the femur fragment, that is in the morphologically central region of the femur, than elsewhere, just as occurs normally. At the extreme distal end of the femur fragment ossification has been completed right across and it is probable that formation of a marrow cavity has begun. That ischium and ilium have developed with a close approach to normality is obvious from the figure. Attached to the posterior end of the ilium is a large piece of cartilage (asterisk) the nature of which could only be determined by sections, but it may be composed of parts of the fused sacral vertebrae. This, of course, is purely a suggestion. Attached to the anterior end of the ilium is another smaller piece of cartilage continued into a long thread of either cartilage or connective tissue, only part of which is shown in the figure. This may be a rib. The precise relations between the proximal end of the femur and the pelvic elements could not be determined with precision. Sections would have been necessary and it was not thought desirable to risk the specimen on the knife for the sake of comparatively small points.

No. 19. Fig. 14.

Origin.—The basal half of a posterior bud of a four-day donor. Side unknown.

Graft (Fig. 14).—This is a very remarkable specimen, for which I have no explanatory hypothesis to offer. It appears to consist of a pelvis piece, which is probably a pubis (*Pelv ?*), of a femur (*Fem*), which is incomplete distally and ends in a point, of a tibia (*Tib*) which is more or less complete proximally, but

tapers off distally to a point just as the femur does, and of a small rod of cartilage lying beside the tibia and probably representing a small fragment of fibula. The femoral region seems to have a head and a trochanter of sorts. It is interesting to note that the distal end of the femur lies in a kind of wide groove on the expanded proximal end of the tibia. The only explanation I can offer for this

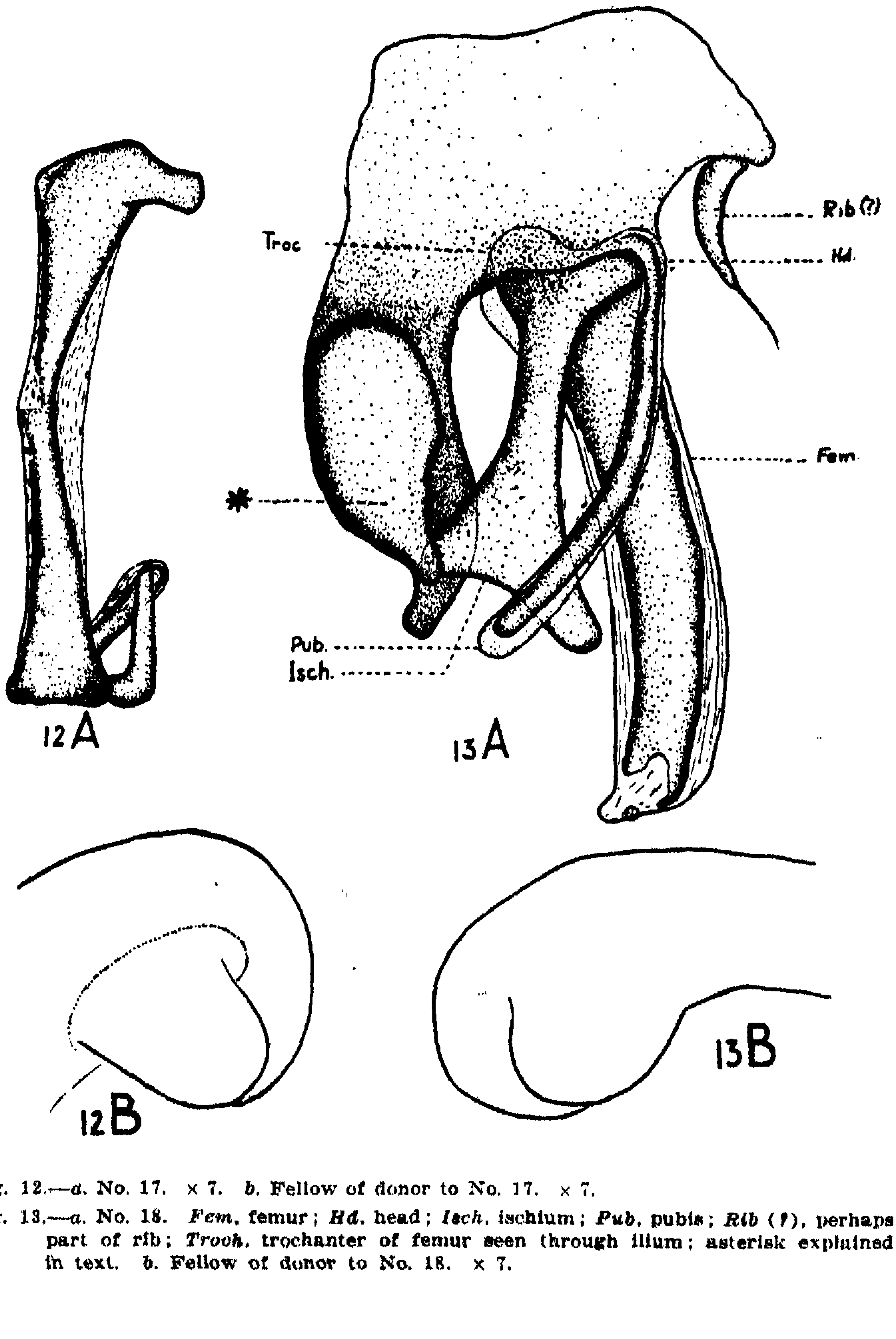


Fig. 12.—*a*. No. 17. × 7. *b*. Fellow of donor to No. 17. × 7.

Fig. 13.—*a*. No. 18. *Fem*, femur; *Hd*. head; *Isch*. ischium; *Pub*. pubis; *Rib (?)*, perhaps part of rib; *Troch*. trochanter of femur seen through ilium; asterisk explained in text. *b*. Fellow of donor to No. 18. × 7.

curious state of affairs is that perhaps the bud received some severe injury in grafting, such as a cut nearly across, resulting in independent development of the two parts, of which one formed an incomplete femur and the other an incomplete tibio-fibula.

Although, since the chick from which the donor bud was taken is not available, it is impossible to say from which side the bud was taken, the position of the supposed pubis suggests that we are looking at the specimen from the anterior aspect in the figure, in which case the head is on the right hand side of the specimen, and it is part of a left limb.

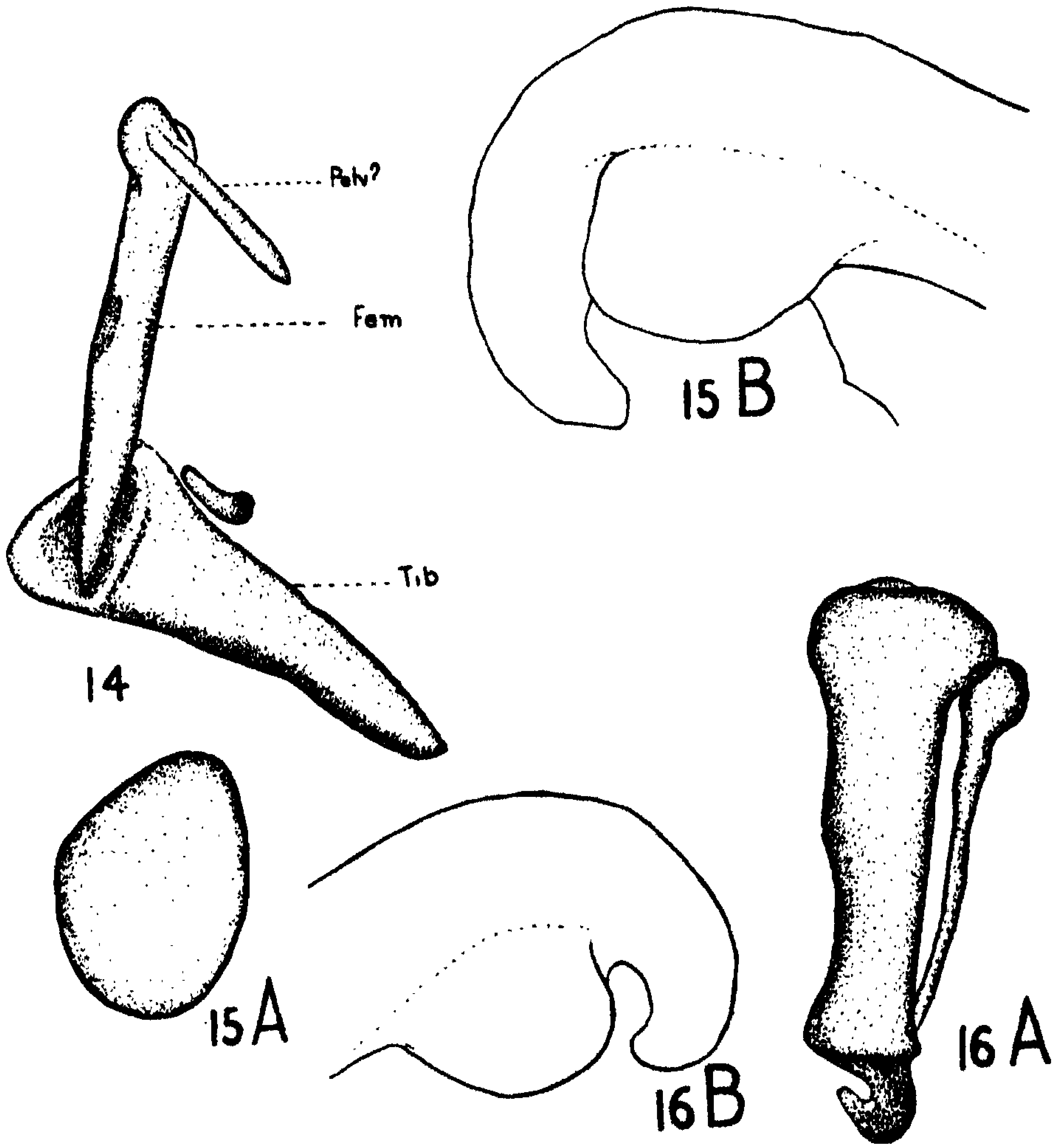


Fig. 14.—No. 19. × 10. *Fem*, femur; *Pelv ?*, pelvis fragment?; *Tib*, tibia.
Fig. 15.—*a*. No. 20. × 28. *b*. Fellow of donor to No. 20. × 10.
Fig. 16.—*a*. No. 21. × 10. *b*. Fellow of donor to No. 21. × 10.

No. 20. Figs. 15*a*, 15*b*.

Origin (Fig. 15*b*).—The basal half of the left posterior bud of a four-day donor.

Graft (Fig. 15*a*).—The graft is a little rounded nodule of cartilage, its chief point of interest being its complete failure to develop into anything more. The significance of this will be discussed at a later stage. The explanation of the failure of this specimen to develop, while other exactly similar ones grow and differentiate well, is probably to be found in some condition on the membrane, such as insufficient vascularization of the original bud fragment. Its cartilaginous nature is confirmed by sections.

No. 21. Figs. 16*a*, 16*b*.

Origin (Fig. 16*b*).—The basal half of the right posterior bud of a four-day donor.

Graft (Fig. 16*a*).—This specimen, which one would have expected to be a femur with or without a tibio-fibula, is actually a tibio-fibula with no femur. This, at least, is the obvious interpretation. The distal end of the tibia is quite abnormal, consisting of a curious hook-like structure. The fibula, on the other hand, is more like the normal, being expanded proximally and ending in a point at the other end. It was thought that the explanation of this specimen, in which we see a basal half of a bud giving rise to a tibia and fibula but to no femur, might be found in the position of the cut which removed the donor bud from the chick. Examination of the donor, however, revealed that the bud had been completely removed, so the region which normally gives rise to the femur must have been included in the graft. The remaining possibility is that the bud may have been badly damaged in its proximal regions during the operation and hence this region was unable to undergo further development.

No. 22. Figs. 17*a*, 17*b*.

Origin (Fig. 17*b*).—The middle third of the left anterior bud of a four-day donor.

Graft (Fig. 17*a*).—The graft is an interesting little structure, which, it must be admitted, would be quite unrecognizable as any definite morphological part if one did not know its origin. In view of its origin, we must regard it as the distal end of a humerus, and an imperfect radius and ulna. This, at any rate, sounds more probable than any other speculation. The structure certainly consists of a single element which is pointed at one end and expanded at the other, joined with another element which is like a flattish plate with a hole in the middle, and which is strongly suggestive of two elements joined side by side by their two ends. It is, of course, very far removed from the normal; nevertheless, the above explanation seems adequate and justifiable. The actual structure has been confirmed from sections.

No. 23. Figs. 18*a*, 18*b*.

Origin (Fig. 18*b*).—The apical half of the right posterior bud of a four-day chick. Sections show it to consist of a dense cellular mass with very slight but definite central condensation.

Graft (Fig. 18*a*).—The graft is a practically complete tibio-fibula and foot. The tibia has an apical end which is, perhaps, more rounded than normally. The fibula appears to be largely ossified. It is free from the tibia proximally, but distally lies very close to it, and at this end stretches as far as the end of the

tibia, while at the proximal end it fails to reach the end of the latter. It is considerably shorter than the tibia, indicating that its growth has been retarded compared to the tibia, as normally occurs, but it has not become fused with the tibia proximally, which, of course, often happens normally. Apparently, its strongest anchorage has been at the distal end of the tibio-fibula and hence it has remained attached here, while remaining free at the proximal end. It would be interesting to know whether any actual fusion has occurred between tibia and fibula at the distal end, but this would have to be done by sectioning and I did not wish to spoil so perfect a specimen. The tarsal region is represented by what seem to be two tarsal elements, though their number is doubtful. They seem to be lying still unfused with either tibia or metatarsals which, of course, is not abnormal. There are four metatarsals, three fused together to form a broad plate with a hole in the middle, the result of incomplete fusion of metatarsal 2 with 3.

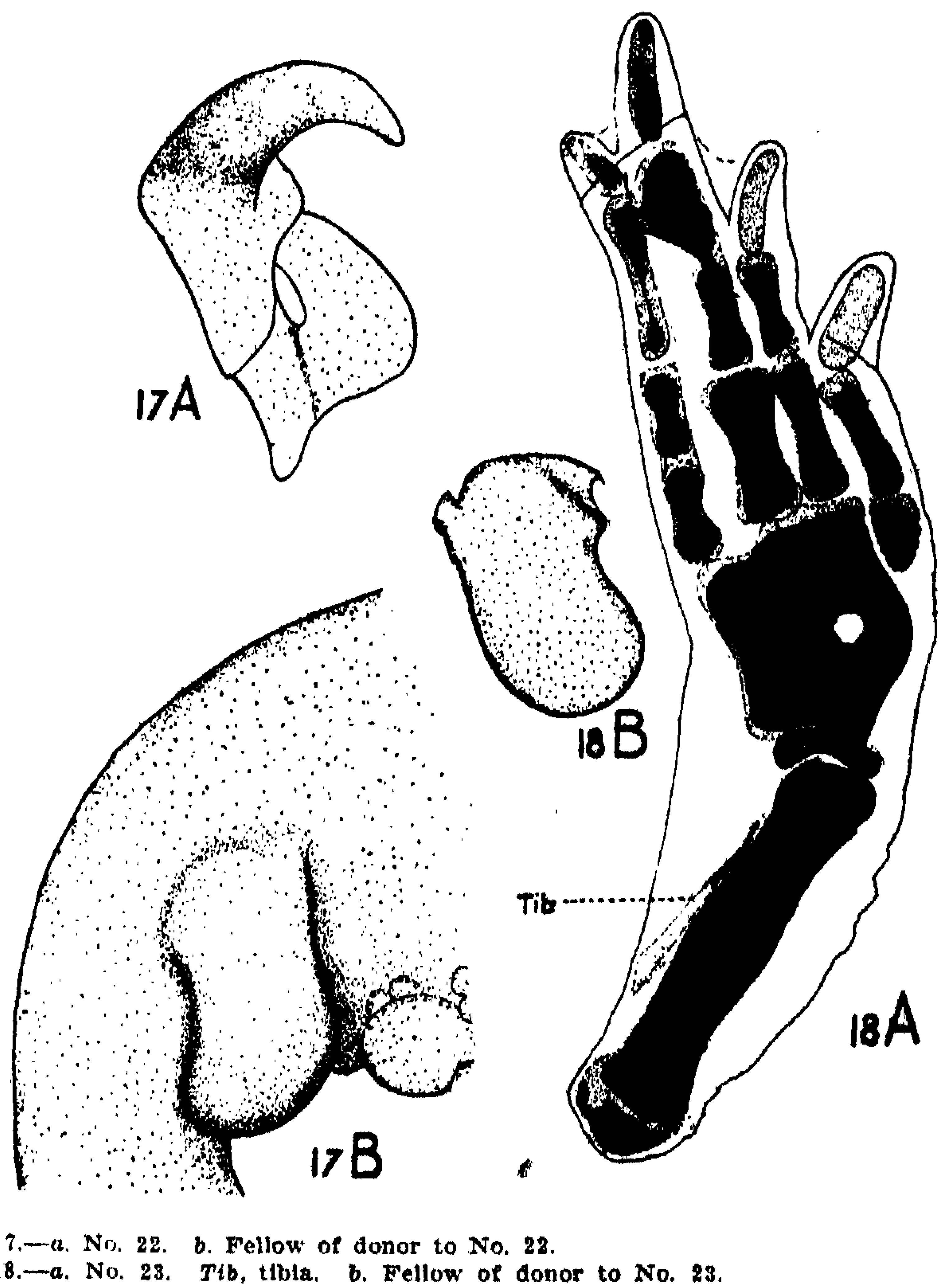


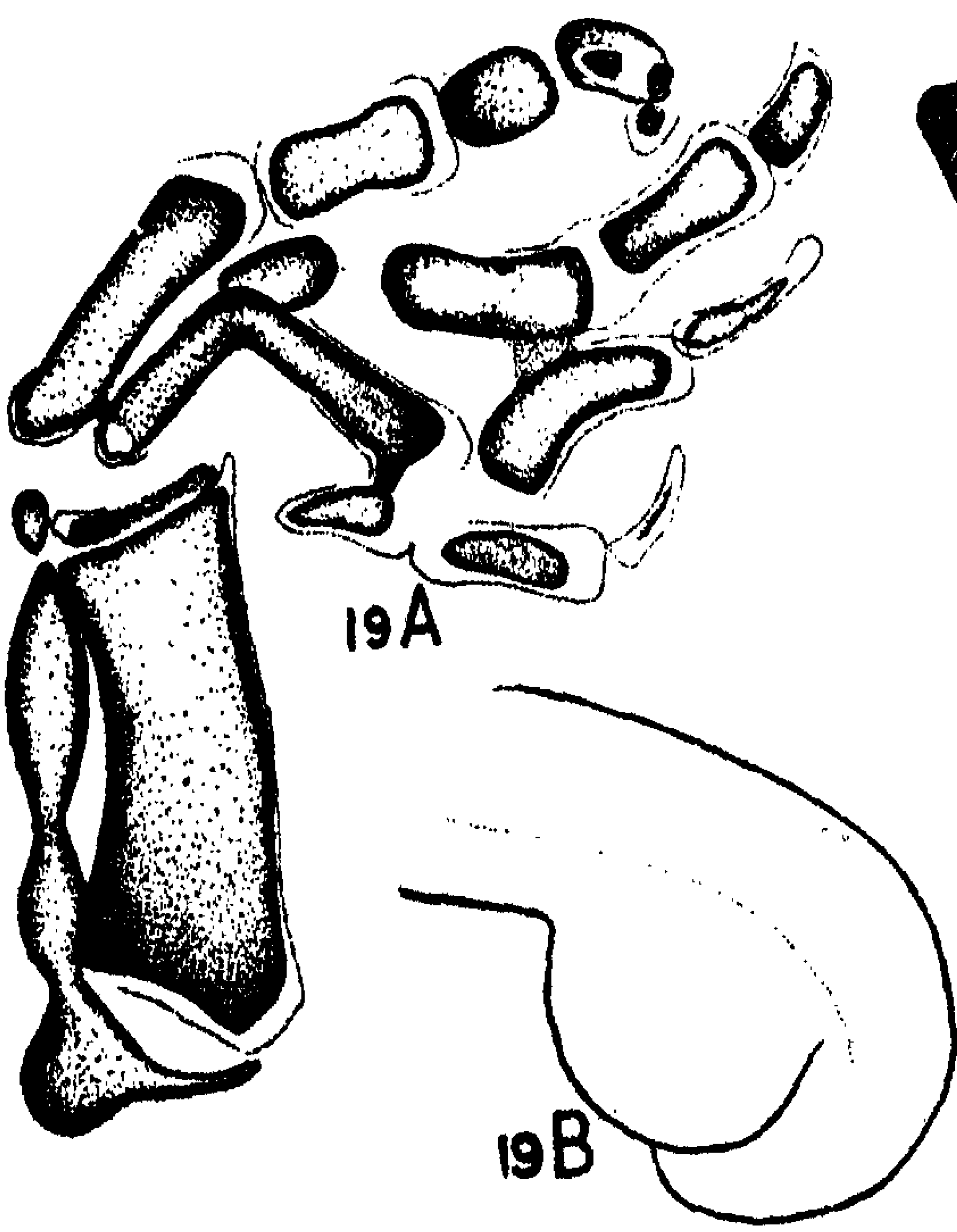
Fig. 17.—*a*. No. 22. *b*. Fellow of donor to No. 22.
Fig. 18.—*a*. No. 23. *Tib*, tibia. *b*. Fellow of donor to No. 23.

Metatarsal 1 is a small cartilage lying lateral to the flat plate. There are four toes of which digit 1 has two phalanges, 2 has three, 3 has four, and 4 has four. These numbers are, of course, normal, except that the fourth toe should have 5 phalanges. The penultimate phalanges of digits 3 and 4 are fused together, phalanges 2 and 3 of digit 3 are fused together and so are phalanges 1 and 2 of digit 4. This fusion would perhaps be more correctly ascribed to a failure to separate.

No. 24. Figs. 19*a*, 19*b*.

Origin (Fig. 19*b*).—The apical half of the right posterior bud of a four-day donor.

Graft (Fig. 19*a*).—A good tibio-fibula and foot, which nevertheless shows a number of abnormalities, the most interesting of which is a bifurcation of one toe in the region of the distal phalanx. The completeness of the tibio-fibula proximally is doubtful, the curious extension of the proximal end of the fibula over the tibia is, of course, abnormal, as also is the curious lobed form of the fibula. The incompleteness of the tibio-fibular region is indicated especially by the fact that the fibula is considerably longer than the tibia. There are two free tarsals. The distorted condition of the foot region is evident from the figure as also are the two fusions between metatarsals 1 and 2, and two contiguous phalanges of the second and third digits. The apical phalanx of digit 4 is double, i.e., this toe has bifurcated at its tip. This is the only instance of bifurcation which I have seen; one case of triplication will be described later.



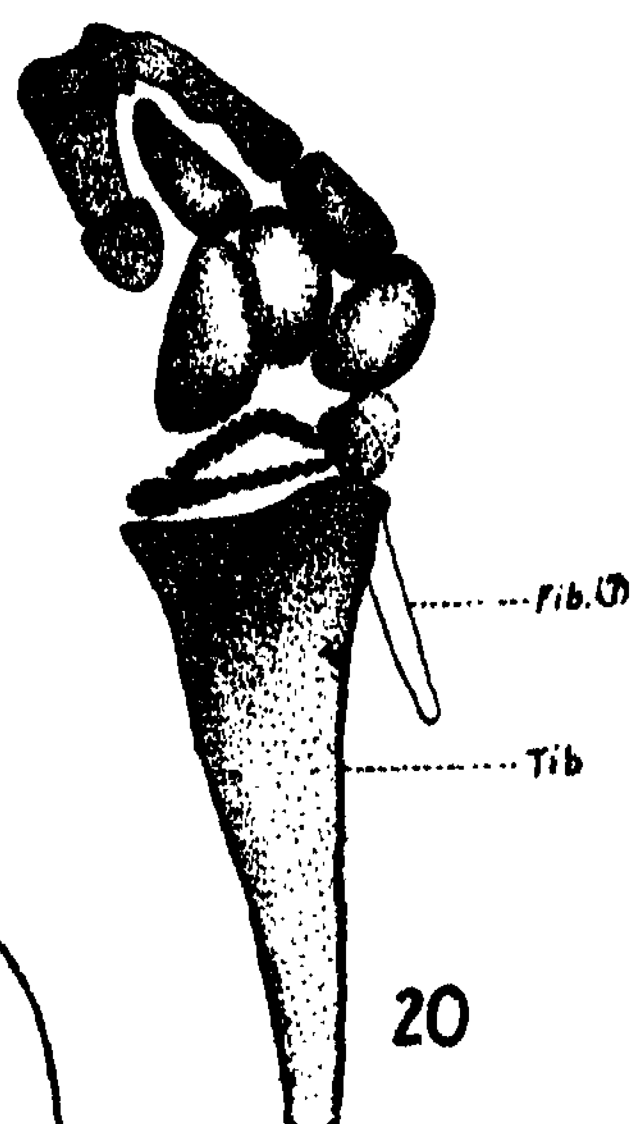


Fig. 19.—*a*. No. 24. × 9. *b*. Fellow of donor to No. 24. × 7.
Fig. 20.—No. 25. × 6. *Fib*, probably fibula; *Tib*, tibia.

No. 25. Fig. 20.

Origin.—The apical half of a posterior bud of a four-day donor, side unknown.

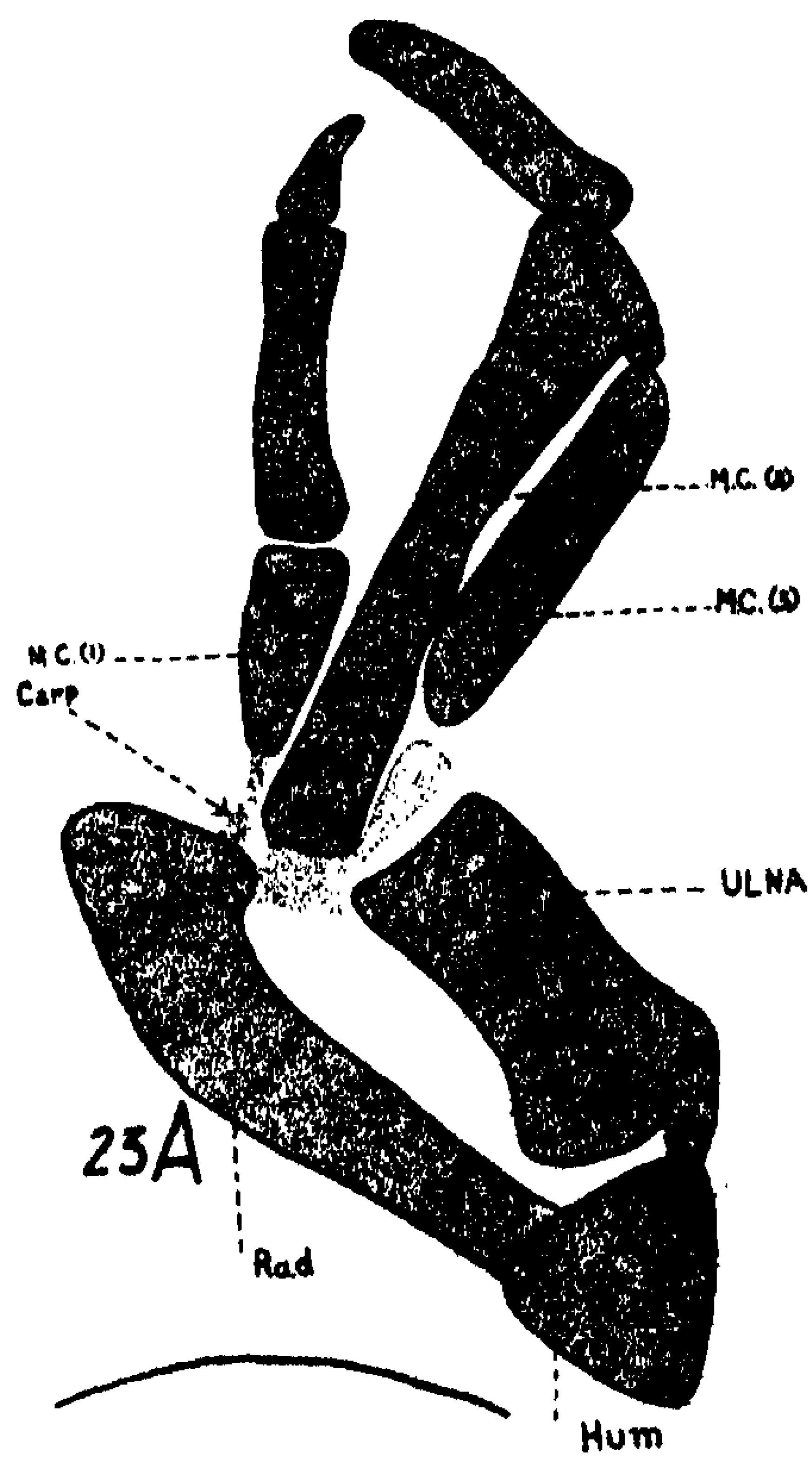
Graft (Fig. 20).—The specimen consists of a foot, with the distal end of a tibia, and what is probably the distal end of the fibula. There are two or three tarsals, and attempts at, probably, four toes, but the toe region is very tangled, and it is difficult, or rather impossible to sort out which phalanges belong to which toes. The most interesting thing about the graft is the incomplete tibia and fibula.

No. 26. Fig. 21.

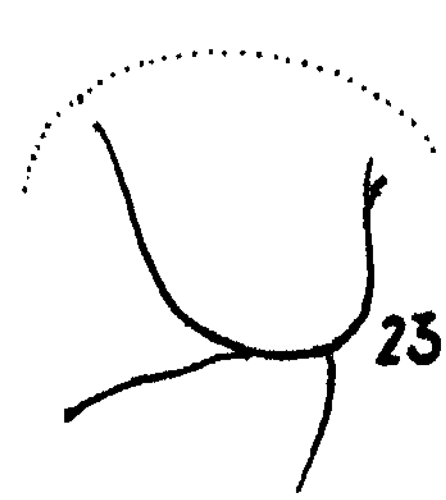
Origin.—The apical half of a posterior bud of a four-day donor, side unknown.

21

22



23A



23B

Fig. 21.—No. 26. × 10.
Fig. 22.—No. 27. × 7.
Fig. 23.—*a.* No. 28. × 9. *Carp*, carpal region; *Hum*, humerus; *M.C.* (1), (2), (3), metacarpals; *Rad*, radius; *ulna*, ulna. *b.* Fellow of donor to No. 28. × 7.

Graft (Fig. 21).—It is chiefly interesting as a failure. Its constitution is shown in the figure. The interpretation is, apparently, that we have here an attempt to make a foot. The graft has succeeded in developing into a structure which has certain resemblances to early stages in the development of a normal foot, being a single piece of cartilage with radiating "toes"—if the fork-like structure can be regarded as an attempt at a pair of toes. The whole structure is a single mass of cartilage, with the possible exception of the little central "toe", which may be separate; the metatarsal region is represented by a single cartilage, while beyond this are the three "toes".

No. 27. Fig. 22.

Origin.—The basal half of an anterior bud of a four-day donor, side unknown.

Graft (Fig. 22).—This is a humerus. There is an expanded head, and distally the end of the humerus has condyloid structures, evidently an approach to the normal condition of this end of the humerus. The whole structure is much bent, and it should be noticed that the ossification, which has been considerable, has occurred predominantly on the concave side. Replacement of cartilage has commenced in the central region.

No. 28. Figs. *23a*, *23b*.

Origin (Fig. *23b*).—The apical half of the right anterior bud of a four-day donor.

Graft (Fig. *23a*).—It is a nearly complete wing. The figure shows a fragment of the distal end of the humerus, a radius and ulna, a doubtful carpal apparatus, *digit* 1, and *digits* 2 and 3, the latter so placed as to indicate clearly that the metacarpal regions foreshadow a carpo-metacarpus. That this structure is the apical three-quarters of a wing is beyond dispute, but the precise nature of some of the constituent parts is less certain. *Hum.* is clearly the distal end of the humerus. *Rad.* is the radius, *Ulna* is the ulna. It is joined to the fragment of the humerus by a cartilaginous bridge, clearly showing that separation had never been satisfactorily completed. The region indicated by *Carp.* is shown in light stipple because the stain here is poor, and the precise number of free carpals is doubtful. M.C. (1) is the metacarpal of digit 1, M.C. (2) of digit 2, and M.C. (3) of digit 3. Digit 1 has two phalanges, digit 2 has one (normally three), and so has digit 3 (the normal number). To what extent carpals have fused with metacarpals to form the carpometacarpus cannot be said, owing to my ignorance of the number and relations of the carpals; nevertheless, the arrangement of metacarpals 2 and 3 is very distinctly suggestive of the general form, at least, of the normal carpometacarpus.

No. 29. Figs. *24a*, *24b*.

Origin (Fig. *24b*).—The apical half of the left anterior bud of a four-day donor, side unknown.

Graft (Fig. *24a*).—Consists of an almost complete wing, the only part missing being the proximal end of the humerus. The humerus is pointed at its proximal end and very short. It is followed by the radius and ulna, two long straight elements. Between the humerus and the ulna, or rather posterior to their junction, is an oval-shaped nodule of cartilage which seems to be quite anomalous. It may be derived from a displaced fragment of humerus tissue. Whether it actually fuses with either the ulna or the humerus, I was not able to determine. Note that radius and ulna are both straight, that both are ossified and that, in both, bone is laid down approximately equally on both sides. Compare with

Figs. 31*a*, 5*a*, 22, etc., where bone is more developed on the concave side of bent elements than on the convex. The radius and ulna are followed, probably, by at least one more or less free carpal. It is always difficult in wing grafts to detect the true number and relations of the small carpal bones. Next come the metacarpals. Metacarpal 1 is followed by a digit of two phalanges; metacarpals 2 and 3 lie side by side and are of approximately equal lengths, suggesting a carpometacarpus and each has a digit of one phalanx. The normal number of phalanges in the toes is, of course, two, three and one, for the first, second and third digits respectively.

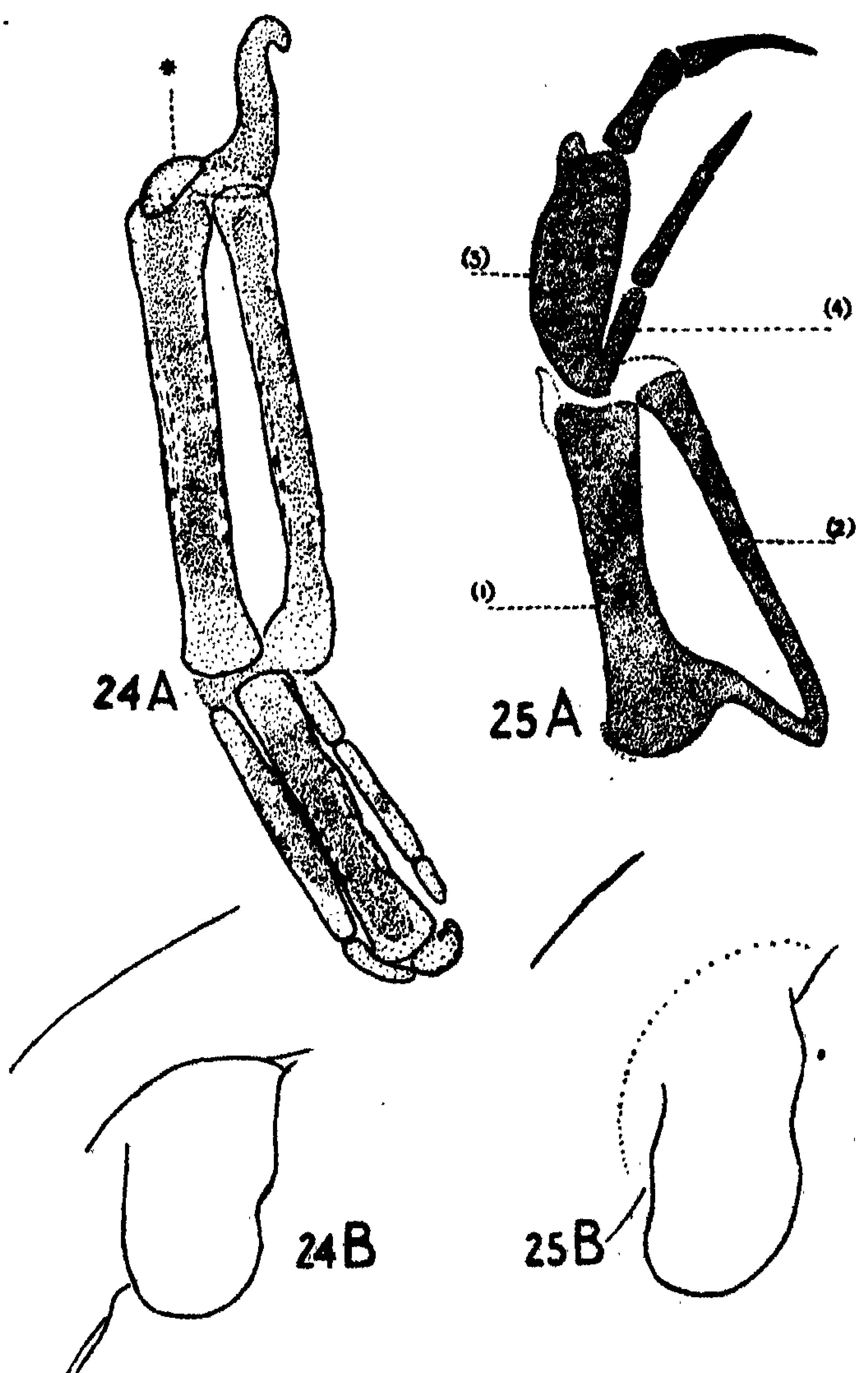


Fig. 24.—*a*. No. 29. Asterisk explained in text. *b*. Fellow of donor to No. 29. × 7.
Fig. 25.—*a*. No. 30; explanation in text. *b*. Fellow of donor to No. 30. × 7.

No. 30. Figs. 25*a*, 25*b*.

Origin (Fig. 25*b*).—The apical half of the left anterior bud of a four-day donor.

Graft (Fig. 25*a*).—This graft evidently consists of the apical region of a wing. So much is obvious at a glance, but further study shows that its precise constitution is less easy to fix. It is possible to regard the two rods of cartilage, (1) and (2), as being the metacarpals of digits 2 and 3, which then simply follow them [(3) and (4)]. But it must be admitted that (1) and (2) are more like a radius and ulna. In this case (3) represents the completely fused metacarpals 2 and 3, while digit 3 is represented by the projection from the anterior end of (3), digit 2 by the digit following on (3), while (4) indicates the metacarpal of digit 1. Then (2) would be the radius and (1) the ulna. Sections show no sign of (3) having originated by a fusion of other elements, and the projection from it does not bear any very great resemblance to a digit. I am therefore inclined towards the first of these alternative views rather than the second. Sections show that bone exists, especially in the angle of (2).

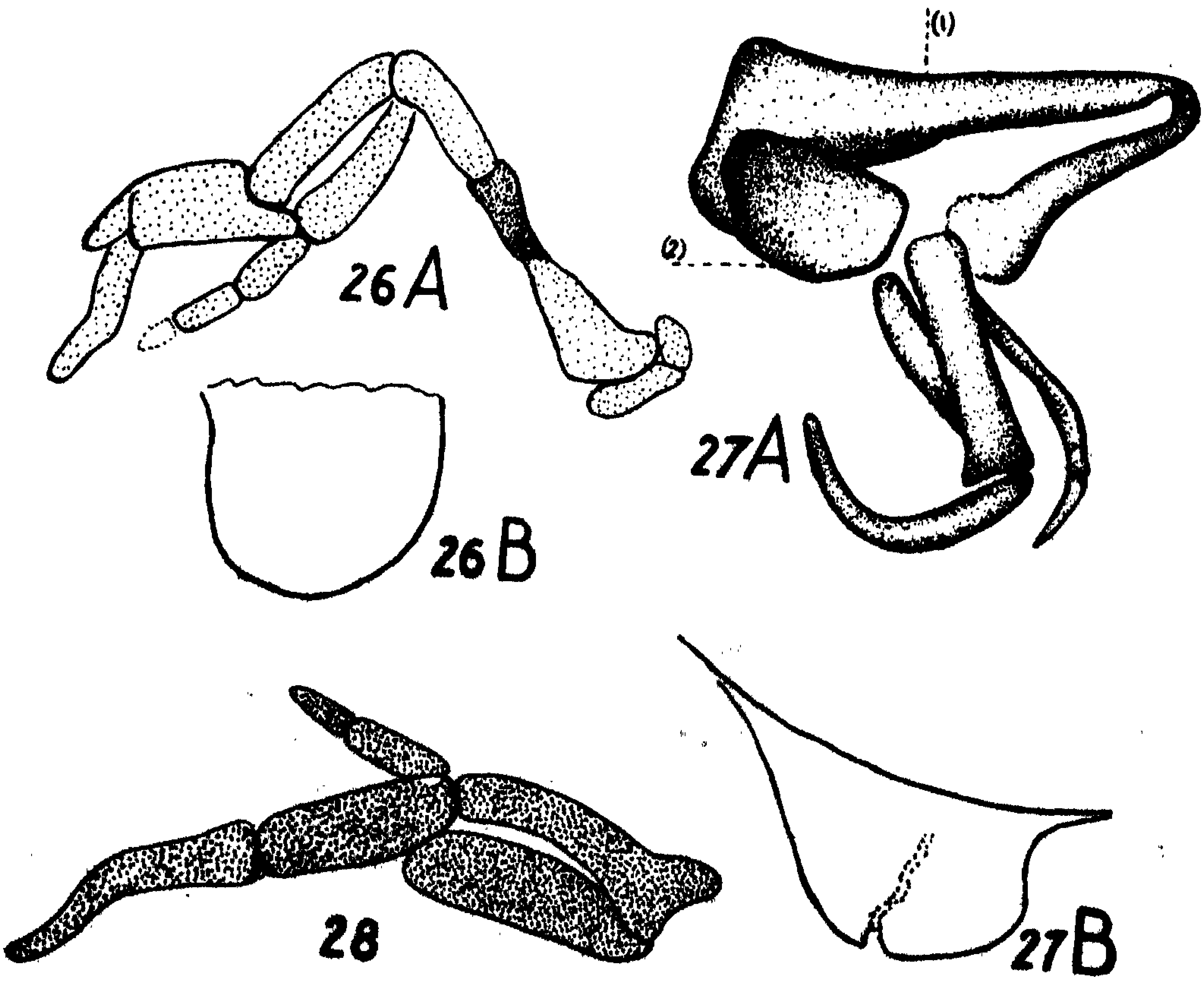


Fig. 26.—*a*. No. 31. *b*. Fellow of donor to No. 31. × 9.
Fig. 27.—*a*. No. 32. × 14. *b*. Fellow of donor to No. 32. × 9.
Fig. 28.—No. 33. × 10.

No. 31. Figs. 26*a*, 26*b*.

Origin (Fig. 26*b*).—The apical half of a fore bud of a four-day donor. Since the homologous bud had been removed from the donor when the examination was made, it is not known from which side it came.

Graft (Fig. 26*a*).—The graft is remarkable in being apparently a complete wing. (It is most unfortunate that its fellow graft from the same bud failed to take). It consists of two little pectoral girdle fragments, which are too small to be identified, of a humerus, which has an expanded head, and an expanded base. The more darkly stippled central region of the humerus differs from the remainder of the humerus in being much more darkly stained, and this region is marked off from the rest of the humerus by the ridges or grooves indicated in the figure. These are frequently found near the end of long cartilages, and perhaps they indicate the boundaries between epiphysis and anaphysis; if so, the anaphysis is extraordinarily short and the epiphysis extraordinarily long in this case. Sections show that the cartilage of the humerus has reached a much more advanced stage of differentiation in its central region than at its ends, and that this region is marked by an abrupt transition from the less developed cartilage at the ends. The wing is complete except that in the carpometacarpus the two metacarpals concerned appear to be fused along their entire length. There are three digits with the number of phalanges shown in the drawing. The existence of the apical phalanx shown on digit 1 is doubtful. The fact that this interpretation requires a complete fusion of metacarpals 2 and 3 together may cause doubts to arise as to its correctness. The only possible alternative view would make my radius and ulna into metacarpals 2 and 3, my femur into either radius or ulna, while one of these two would be absent, my two pectoral girdle fragments would be quite unexplained, while so also would be my third digit.

No. 32. Figs. 27*a*, 27*b*.

Origin (Fig. 27*b*).—The apical half of the right fore bud of a four-day donor. The split shown in the figure of the homologous bud is an accidental injury which was inflicted upon it, not upon the bud used for the graft.

Graft (Fig. 27*a*).—This graft consists of a distorted wing apex. Of (1) and (2), one is a radius and one an ulna, but it is impossible to say which is which. There are three digits following upon the radius and ulna, but as they do not lie in such a manner as to show which pair is to give rise to a carpometacarpus, it is impossible to say which is digit 1, 2 or 3. Two of the three digits are clearly shown in the figure, while another lies partly beneath the uppermost digit.

No. 33. Fig. 28.

Origin.—The apical half of a fore bud of a four-day donor, side unknown.

Graft (Fig. 28).—The graft consists of a wing apex, consisting clearly of the two digits 2 and 3. The two metacarpals lie side by side as though preparing to form a carpometacarpus, and are followed distally by two digits of two phalanges each. That both digits appear to arise from the same metacarpus is probably due to distortion in development, or possibly to an unreal appearance in the cleared specimen. The reasons for believing these two digits to be the second and third are (1) the resemblance of their metacarpals to a carpometacarpus, (2) the fact that these two digits are the most distal, and the graft originated from an apical half. Hence, while the anlagen of basally situated structures

could be absent, those of distally situated structures could not. The expanded proximal end of one of the two metacarpals indicates that this region should be regarded as complete in the graft.

No. 34. Fig. 29*a*.

Origin.—The anterior longitudinal half of a posterior bud of a four-day donor, side unknown.

Graft (Fig. 29*a*).—The graft consists of a femur, an element which from its form and origin (anterior half) would appear to be the tibia, a small fragment at the proximal end of the tibia which probably represents part of the fibula, and two toes, much distorted. There is also a pelvic structure at the proximal end of the femur. The femur has no head and no trochanter, and distally it ends in a rounded expansion. Throughout its length it is of such a form that it would be more or less circular in cross-section. Ossification has been considerable, and

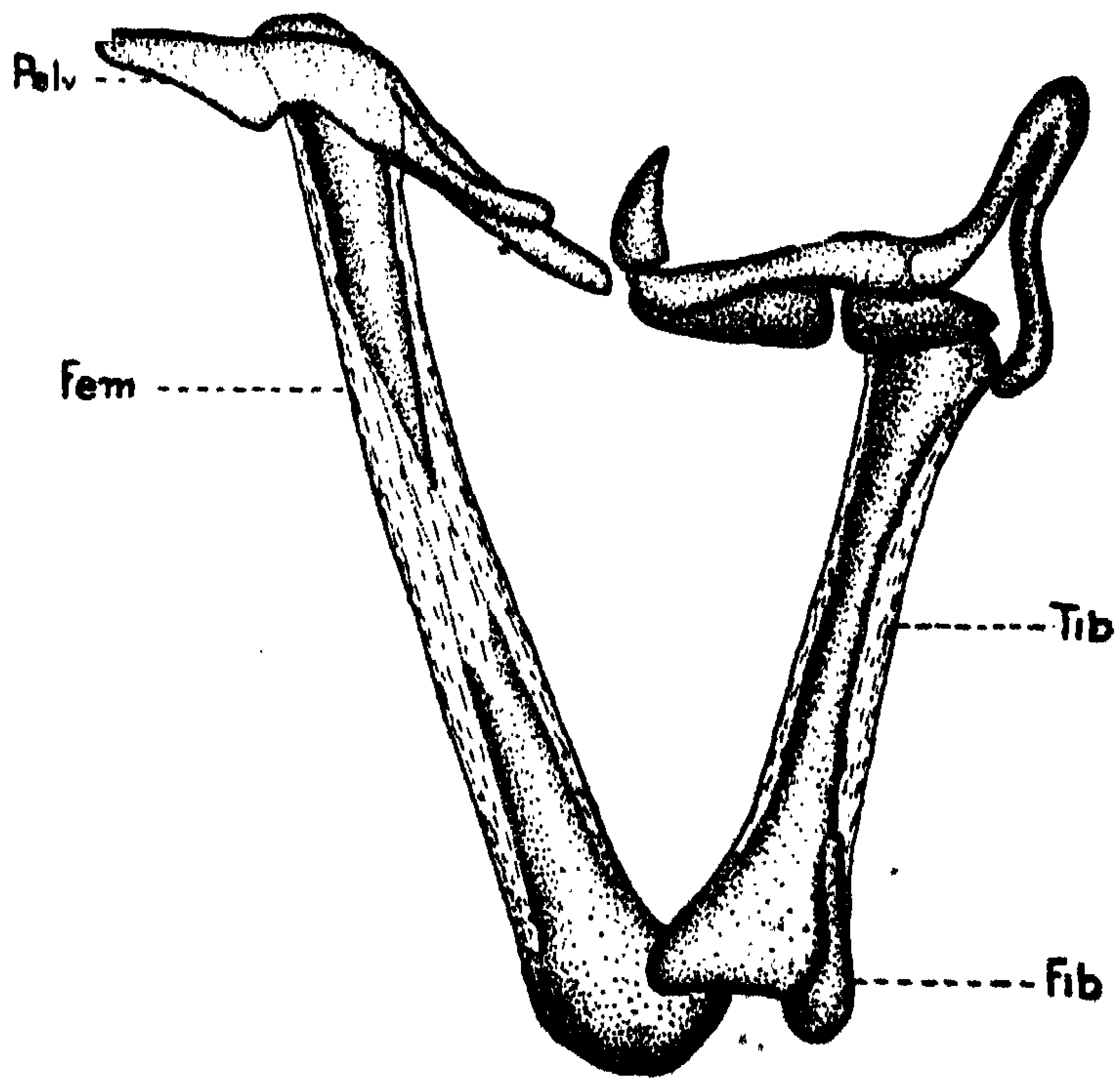


Fig. 29*a*.—No. 34. × 8. *Fem*, femur; *Fib*, fibula; *Pelv*, pelvic fragment; *Tib*, tibia.

the whole of the element, except the ends, is ensheathed in bone. The replacement of the cartilage in the middle of the femur has also proceeded to such an extent that the cartilage seems to have disappeared altogether in the central region. The tibia is expanded at the ends, but it cannot be said that its joint structures are normal. There is no sign of condyles at its distal end. There has been considerable ossification here also. The two toes are, as already stated, much twisted. One seems to consist of a metatarsal and one phalanx, while the other consists of a long metatarsal and two phalanges. It is doubtful

whether a patella exists or not. It has not been shown in the figure. As regards the identification of the toes, from the origin of the graft and the number of phalanges they would appear to be Nos. 1 and 2.

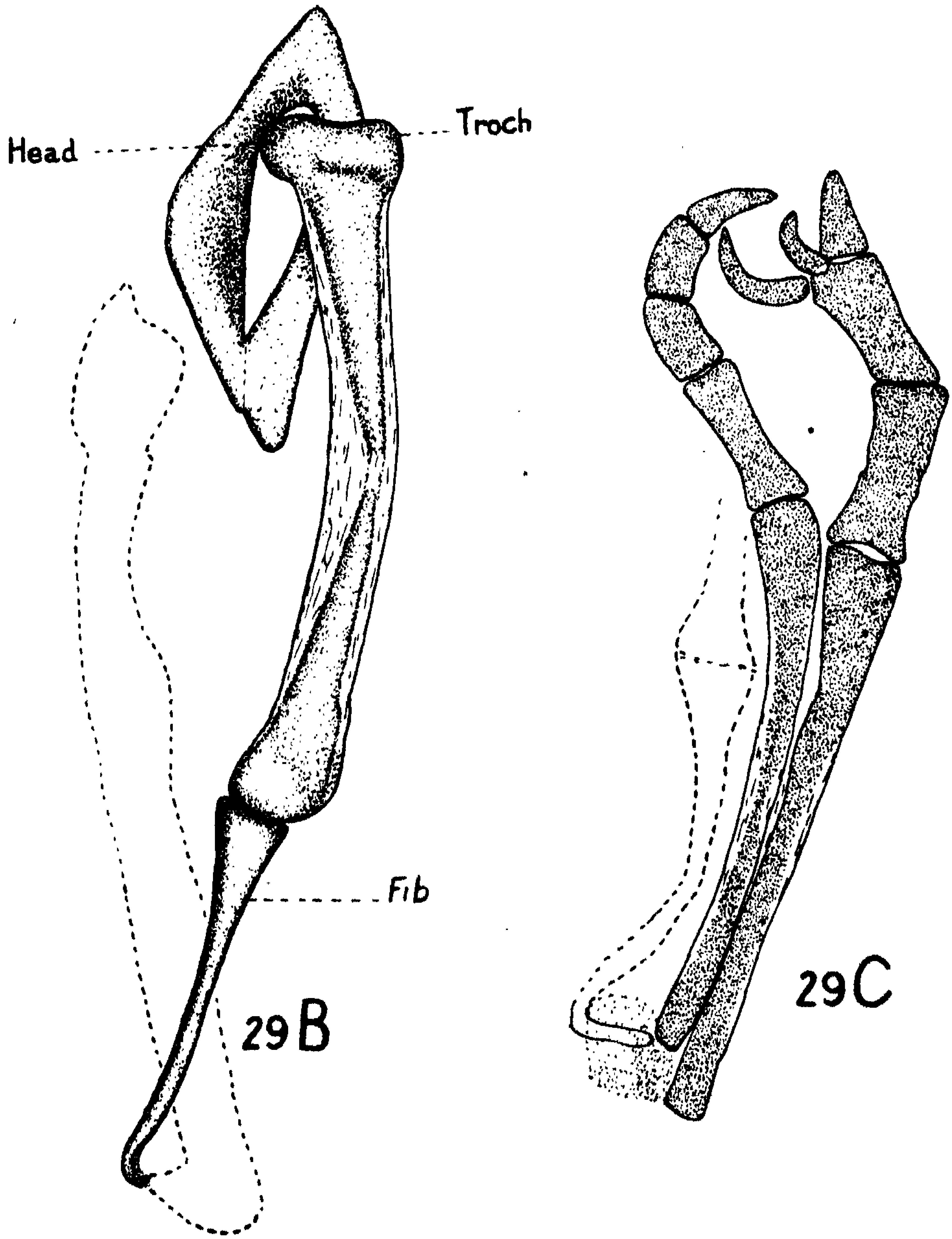


Fig. 29.—*b*. Femoral and fibular region of No. 35. × 8. *Fib*, fibula; *Troch*, trochanter. *c*. Foot region of No. 35. × 8.

No. 35. Figs. 29*b*, 29*c*.

Origin.—The posterior longitudinal half of a posterior bud of a four-day donor. From the same bud as No. 34.

Graft (Figs. 29*b*, 29c).—Fig. 29*b* shows the femoral and fibular regions of the graft, while the dotted line indicates the outline of the foot region. The latter is shown in Fig. 29*c*, where the fibular region, and the distal end of the femoral region, are indicated by dotted lines. The figure is in two parts thus, because the two regions of the specimen were lying in planes at right angles to one another, with the point of bend at the distal end of the fibula. Fig. 29*b* shows the femur, with well developed head and trochanter, and a shaft which, while bent approximately in the normal direction, would be more or less circular in cross-section. Distally, the femur ends in a rounded expansion. It should be noted that if these two rounded expansions, that of the femur in this graft and

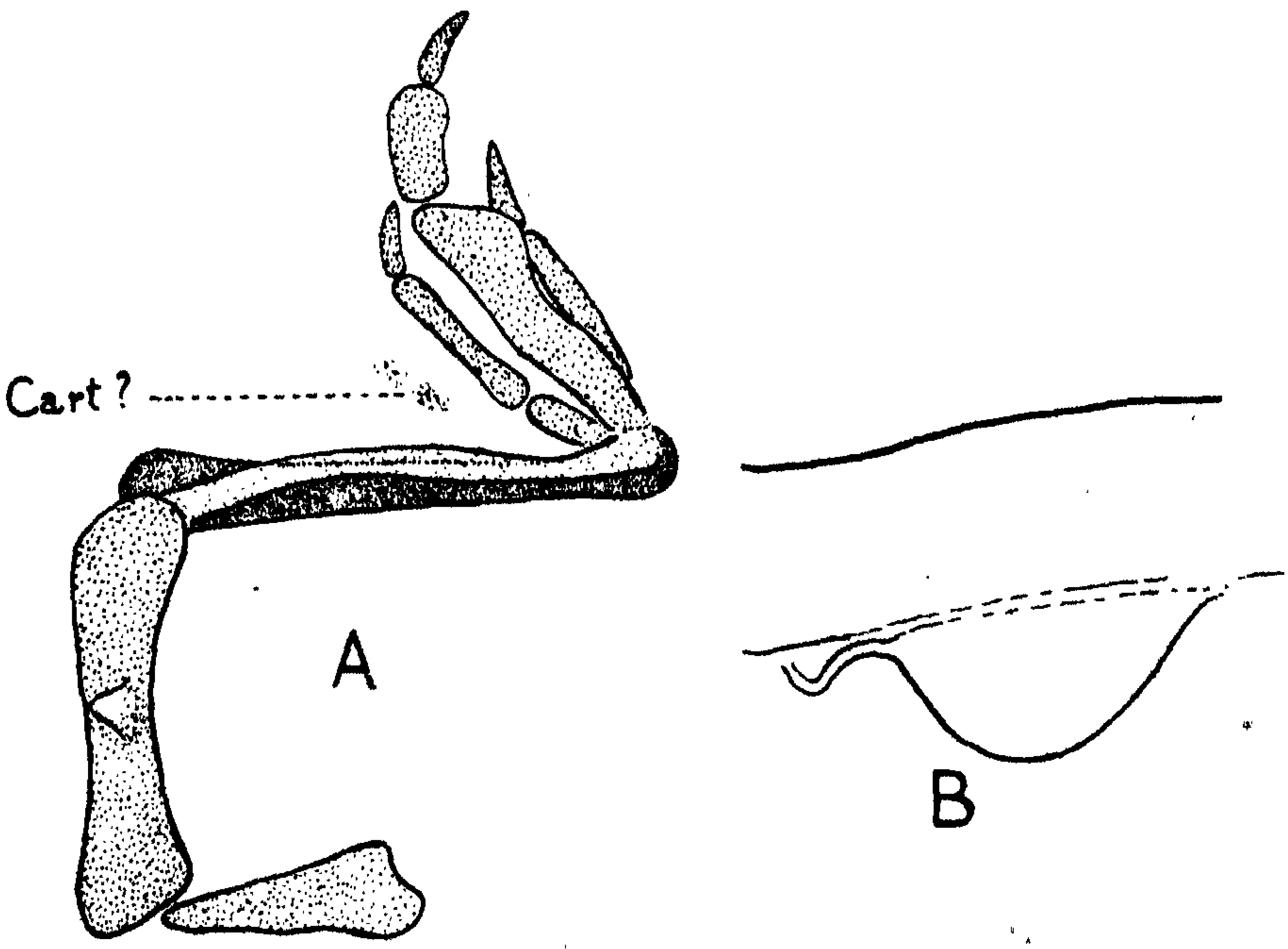


Fig. 30.—*a*. No. 36. *Cart ?*, possibly pieces of cartilage. × 8. *b*. Fellow of donor to No. 36. × 9.

that of the fellow femur in No. 34, were added together, so to speak, a pair of condyles would be formed. At the proximal end of the femur is a pelvic structure which appears to consist of two bars of cartilage joined at their ends. The femur is well ossified, most of the bone is, as usual, deposited on the concave side, and replacement of the cartilage has begun in the central region. Distal to the femur, and shown in the same figure, is a slender cartilage, which from its form and origin (posterior half of bud) must be the fibula. This has an expanded proximal end, while distally it turns abruptly downwards, and appears to end in an abrupt point near the proximal ends of the metacarpals. The details of the region between the distal end of the fibula and the proximal ends of the metatarsals are not known. There appear to be some small tarsal bones present, but

their small size and poor staining render it impossible to describe or to figure them in detail. Fig. 29*c* shows this latter region, and distal to it two long metatarsals. These have a certain amount of bone deposited round them. Distal to them come two toes, one with four phalanges, and the other with three, counting the last triplicated phalanx as one. This last phalanx is triplicated. The three elements seem to lie in one plane, but there is no way of telling to what extent they follow Bateson's Rules of Symmetry or Przibram's Rules for "Bruchdreifachbildungen". These toes are, presumably, the third and fourth.

No. 36. Figs. 30*a*, 30*b*.

Origin (Fig. 30*b*).—A longitudinal half of an anterior bud of a four-day donor. It is not known whether it is an anterior or posterior half.

Graft (Fig. 30*a*).—The graft is remarkable in that it is an apparently complete wing. It consists of a piece of pectoral girdle, a humerus, radius and ulna, and three digits. The humerus is expanded at the two ends, but its extremities are far from having the normal form. About the middle of its length a curious spike of cartilage sticks up on one side. The element which is probably the ulna (rather than the radius) is long and slender while that which is probably the radius is stouter. The reasons for these identifications are given below. Both these cartilages are expanded at their ends. Beyond the radius and ulna lie three toes. The middle of the three, obviously the second toe, has a larger metatarsal than any of the others and two phalanges. That to the right of it consists of a metatarsal and a single phalanx, while that to the left consists of a short metatarsal and two phalanges. The latter would appear to be the preaxial digit, in which case the one on the right of the three is digit 3 and forms part of the carpometacarpus.

I have identified the radius and ulna to accord with this conclusion, though it involved making the stouter of the two elements the radius and the more slender the ulna. If I insist upon calling the more slender of the two rods the radius, then the carpometacarpus must be formed from the central and the left of the three digits. The left digit, however, has three phalanges, whereas it should on this supposition have only one, while its metacarpus, which actually is much the shortest of the three, should be at any rate more or less commensurable in length with that of the central digit. Further, the digit on the right should have a short metacarpus instead of a long one, and two phalanges instead of one. For these reasons I am inclined to regard the more slender of the two rods as the ulna and the thicker as the radius, though this reverses the normal condition.

It must be remembered that, in spite of its completeness, this graft originated from part only of a bud. Now, it is very possible that in making the cut which separated the donor bud into two longitudinal parts, one "half" was made much bigger than the other. The graft from the larger piece would naturally be a nearly complete wing. Now, this graft shows signs of being nearly complete, but not quite. These signs are the spike-like projection of the humerus and the pointed ending of the pelvic element near the proximal end of the humerus. It is quite possible that the reason for the thinness of the more slender of the two rods of the forearm may be that the slender one lies on the side near the cut, and part of its material was removed when the cut was made. This would explain a stout radius and a slender ulna, and also the spike on the humerus and the pointed end to the girdle element, all of which, it should be noted, indicate incompleteness on the same side.

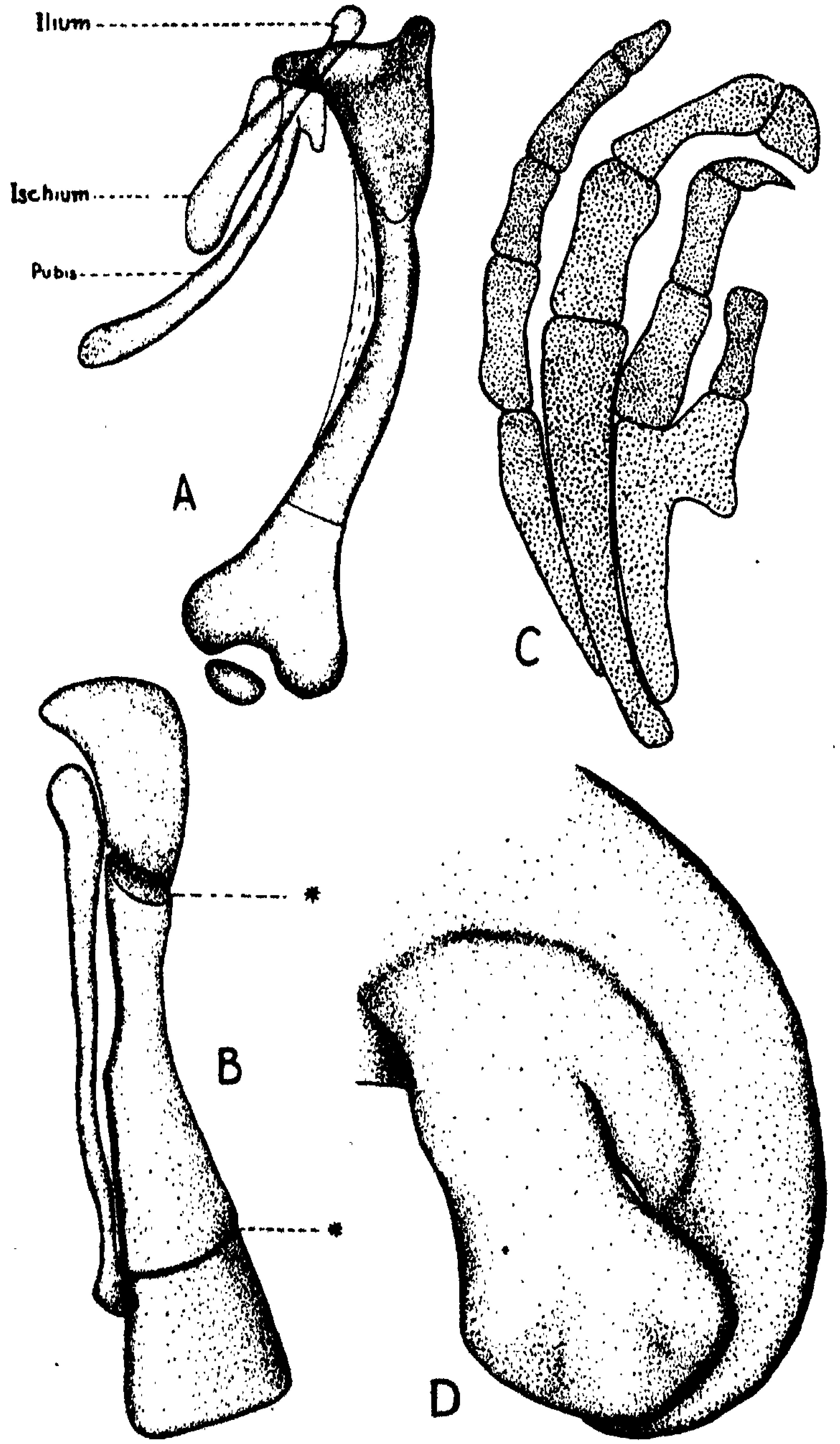


Fig. 31.—*a.* No. 37. *b.* No. 38. Asterisks explained in text. *c.* No. 39. *d.* Fellow of donor to Nos. 37, 38, 39.

No. 37. Figs. 31*a*, 31*d*.

Origin (Fig. 31*d*).—The basal quarter of the right posterior bud of a five-day donor. The bud has a large flattened foot plate, with ridges marking the positions of at least three toes. Median sections show that the skeleton of the fellow limb-bud is clearly marked out in very early cartilage in which only a very small amount of matrix is as yet present. In view of the existence of a patella in the graft, I tried to detect it in the bud, but was unable to do so.

Graft (Fig. 31*a*).—This femur is the most perfect I have seen. The head and trochanter are both very well formed indeed and there is an excellent patella in the correct position. The curved form of the normal femur is beautifully shown, and the central region of the femur is encircled with a veil of bone. Note that this is very obvious on the concave side, while on the convex side it is barely detectable, so little so, indeed, that it has not been shown in the figure. It is, nevertheless, probably present there. Parts of a pelvis are present. These are evidently the pubis and the ischium. The head of the femur is encircled by a ring of cartilage, of which at least that part above the head of the femur must represent a fragmentary ilium, as also, probably, does the continuation of the same ring of cartilage forming a kind of projection from the pubis.

No. 38. Figs. 31*b*, 31*d*.

Origin (Fig. 31*d*).—From the same bud as in No. 37 and 39, the second quarter from the base.

Graft (Fig. 31*b*).—Consists of what appears to be a complete tibio-fibula. That it is a tibio-fibula is indubitable, the only doubtful point is its completeness. There are three reasons for believing it to be complete: (1) The tibia is markedly larger at the ends than in the middle. If it were incomplete one would expect either one end thick and the other tapering to a point, or else neither end very markedly thicker than the other. This expectation is based upon examination of those incomplete elements in other grafts, where the incomplete end is pointed, or at least never thicker than the regions not at the end of the element. (2) The entire length of the fibula seems to be present, since the ends of the tibia go beyond it in both directions. (3) The lines marked with an asterisk on the tibia are exactly like those found frequently on various elements, and nearly always found nearer the end of the bone than the centre, with one or two rare exceptions. For these reasons and from the appearance of the graft we may with safety conclude that we are dealing with a complete tibio-fibula. The condyles normally found at the distal end of the tibia have completely failed to develop as also have the complicated joint structures at the proximal end.

No. 39. Figs. 31*c*, 31*d*.

Origin (Fig. 31*d*).—The distal quarter of the same bud as Nos. 37 and 38.

Graft (Fig. 31*c*).—It consists of a nearly, if not quite, complete foot, consisting of four metatarsals, of which 1 and 2 are fused together, and four toes. The distal phalanx of the first toe is missing. I am almost sure that this was removed accidentally in dissection. The reason for doubting the completeness of this foot is the fact that the metatarsals end in points proximally.

It should be pointed out here that Nos. 37, 38 and 39 constitute a set of grafts all from the same bud, and that this set would be complete had the second quarter from the apex taken.

No. 40. Fig. 32*a*, 32*c*.

Origin (Fig. 32*c*).—The basal half of the left posterior bud of a five-day donor.

Graft (Fig. 32*a*).—It consists of a femur and part of the tibio-fibula. Fig. 32*a* shows only the distal end of the femur. At the proximal end it has a head and trochanter, and two pelvic elements. It is a well-formed femur with a considerable amount of ossification. Distally the femur ends without very well formed condyles. It is followed by an incomplete tibio-fibula, both tibia and fibula ending in points (actually, the fibula has a slight expansion at its distal end and so this may be complete). At the point of apposition between tibia and femur is a nodule of cartilage which must be a patella.

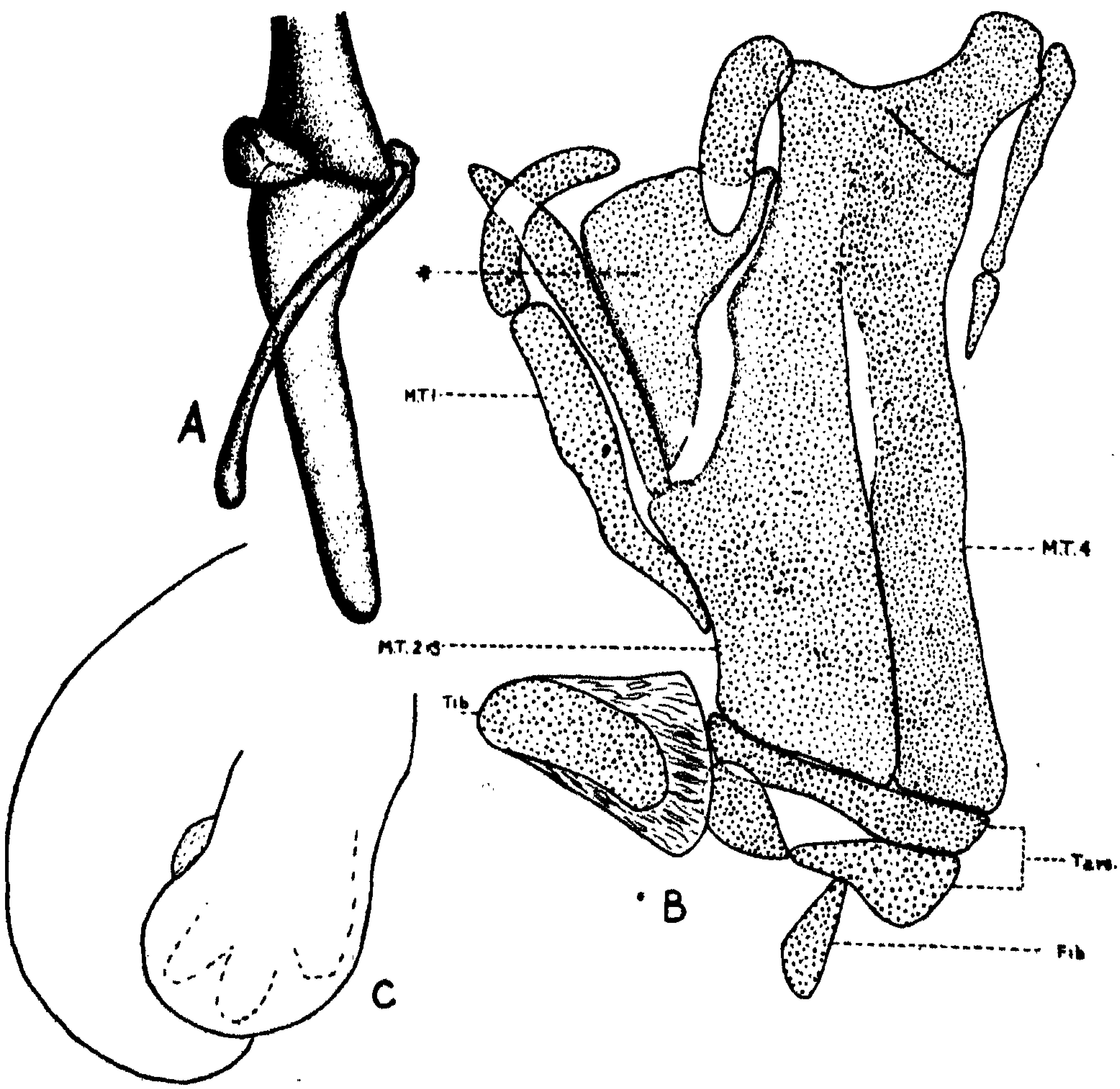


Fig. 32.—*a*. Distal region of No. 40. × 5. *b*. No. 41. *Fib*, fibula; *M.T.* 1-4, metatarsals; *Tars*, tarsals; *Tib*, tibia; asterisk explained in text. *c*. Fellow of donor to Nos. 40, 41; × 7.

No. 41. Figs. 32b, 32c.

Origin (Fig. 32c).—The apical half of the same bud as No. 40.

Graft (Fig. 32b).—A curious flat structure, of very abnormal form, but containing the elements of a foot clearly recognizable. At the proximal end are the fragments of the distal ends of the tibia and fibula. Notice that the end of the tibia is thickened distally, while the end of the fibula is pointed distally. Ossification has occurred in the tibia. It is unusual that this should be the case, since this is the *end* of the tibia, and ossification, in the long bones at least, normally commences in the centre of the bone and then spreads to the ends. The tibia and fibula are followed distally by, apparently, three tarsals, though possibly there may be only two, the proximal one being constricted in the middle. Four metatarsals are present. Metatarsal 1 lies free, but 2 and 3 are fused together, while 4 is fused with 3 at least distally. The four digits are all short, only No. 4, which has two phalanges, having more than one. The plate-like cartilage marked with an asterisk seems to be quite anomalous.

No. 42. Figs. 33a, 33c.

Origin (Fig. 33c).—The proximal half of the right posterior bud of a five-day donor.

Graft (Fig. 33a).—The graft consists of a pelvis, femur, and a fragment of tibio-fibula. The pelvis consists of 3 or 4 long thin rods meeting in a point in a direction proximal to the proximal end of the femur. These rods really resemble

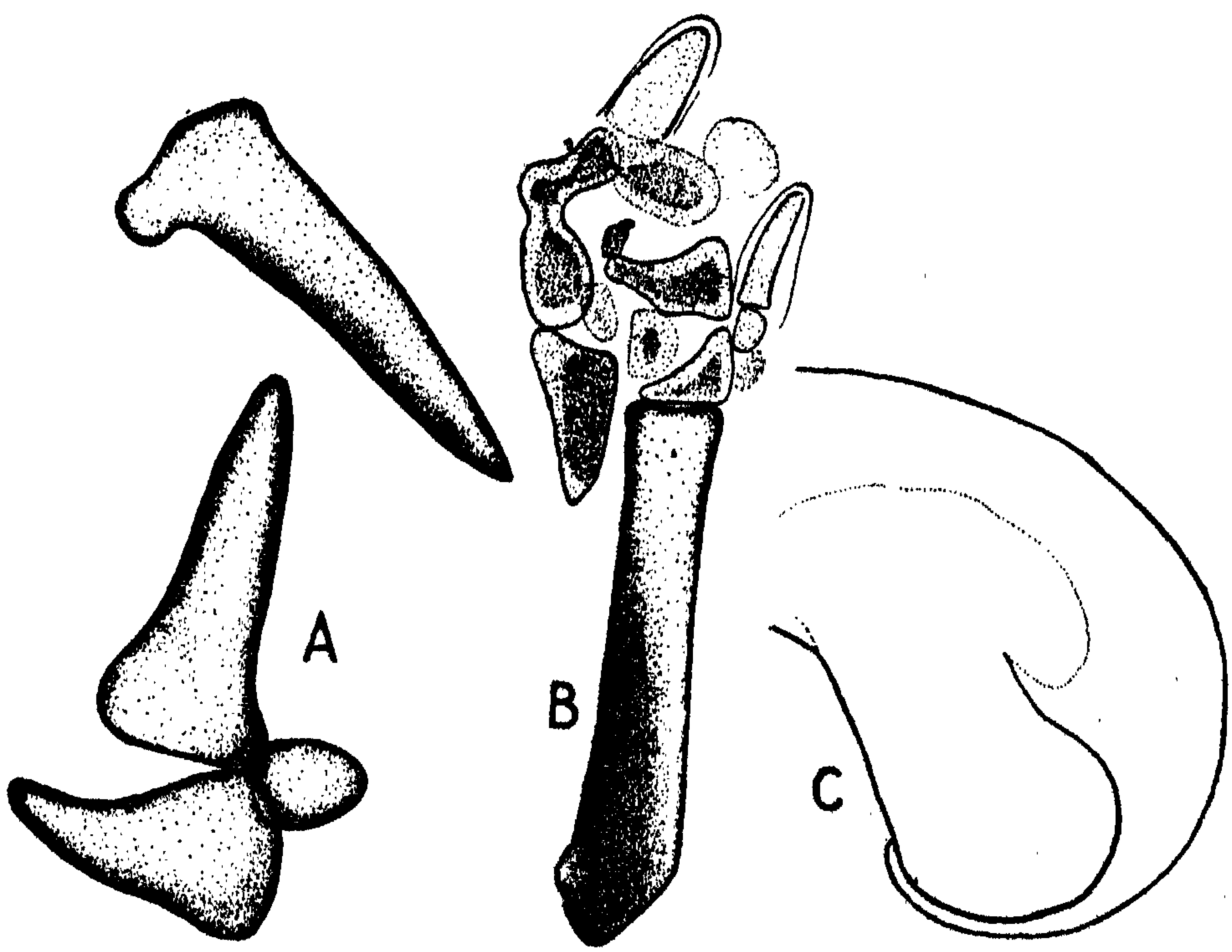


Fig. 33.—a. No. 42. b. No. 43. c. Fellow of donor to Nos. 42, 43. × 7.

ribs more than a pelvis, but from their position they probably represent a pelvis rather than ribs. There is also another cartilage suggestive of transverse processes of vertebrae. These have not been figured. The femur is remarkable in being completely divided into two parts. The proximal part has at its proximal end a head and a trochanter, but distally it ends in a point. The distal part ends in a point at its proximal end, but distally expands considerably, without, however, forming condyles. The tibio-fibula consists of a larger portion, probably the tibia, which while expanded proximally ends distally in a point, and of a fibular element. A patella was not detected.

No. 43. Figs. 33*b*, 33*c*.

Origin (Fig. 33*c*).—The distal half of the same bud as for No. 42.

Graft (Fig. 33*b*).—Part of tibio-fibula, and a distorted foot. The tibia is a large element, whose pointed proximal end indicates incompleteness. Near its proximal end is a small nodule of cartilage which may be the patella, but would seem to be more probably a piece of the fibula. The remainder of the fibula lies beside the distal end of the tibia. Beyond the tibio-fibular region lies a contorted and incomplete foot. In view of the fact that other specimens show conclusively the ability of fragments of similar origin to this one to form complete feet, no attempt has been made to work out the homologies of the complicated group of cartilages which represents the foot in this specimen.

No. 44. Figs. 34*a*, 34*b*.

Origin (Fig. 34*b*).—The basal half of the left posterior bud of a five-day donor.

Graft (Fig. 34*a*).—The specimen consists of a femur, pelvis in three parts and the proximal ends of the tibia and fibula. The head of the femur is well developed, though of somewhat abnormal form. The trochanter appears not to have developed. At the distal end of the femur there are fairly well developed condyles. The presence of a patella is very doubtful, but it may be present at the point marked with an asterisk where I suspect the presence of a small discrete piece of cartilage. Following the femur in the distal direction come the tibia and fibula. The element which is probably the tibia is a large rounded cartilage, while the fibula is a more slender rod. It is obvious that only the most proximal region of the tibio-fibula is present. The pelvis consists of the three elements—ilium, pubis, and ischium. The ischium and ilium lie side by side in the medial direction from the femur, the pubis alone on the opposite side. The acetabulum is not complete. The tibia and fibula are thus identified from their position; the fibula on the side opposite to the head of the femur.

No. 45. Figs. 35*a*, 35*c*.

Origin (Fig. 35*c*).—The basal half of the right anterior bud of a five-day donor.

Graft (Fig. 35*a*).—It consists evidently of a humerus and two pieces of pectoral girdle. The latter are probably the scapula (*Scap*) and part of the coracoid (*Cor*). If this fragment is really the coracoid, its pointed end indicates its incompleteness, and the same applies if it is the clavicle. Lying against the distal end of the scapula (relative to the humerus) is a short bar of cartilage, the nature of which I do not know. Also of the two rods marked with an asterisk, the outer lies free as shown, but the inner one was discovered in sections to be a projection from the humerus, with which it is completely fused at its proximal

end. I am quite ignorant of the nature of the outer one. Perhaps it is a rib. The proximal end of the humerus is expanded and fairly normal in general appearance, but the distal end has only made a feeble attempt to develop condyles.

No. 46. Figs. 35*b*, 35*c*.

Origin (Fig. 35*c*).—The apical half of the same bud as for No. 45.

Graft (Fig. 35*b*).—That this specimen is the apical region of a wing there can be no room for doubt, nor that the proximal region is entirely absent.

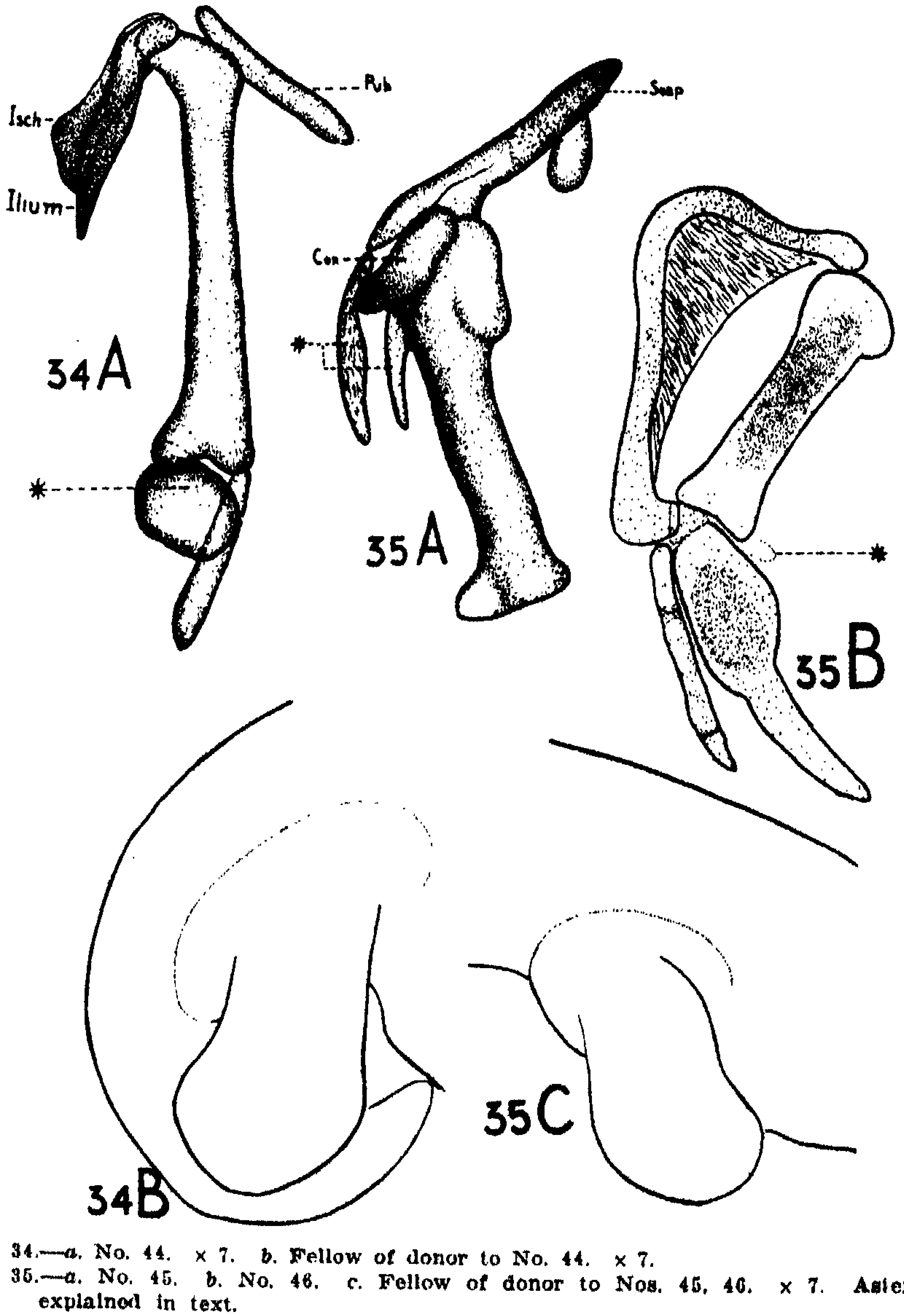


Fig. 34.—*a*. No. 44. × 7. *b*. Fellow of donor to No. 44. × 7.
Fig. 35.—*a*. No. 45. *b*. No. 46. *c*. Fellow of donor to Nos. 45, 46. × 7. Asterisks explained in text.

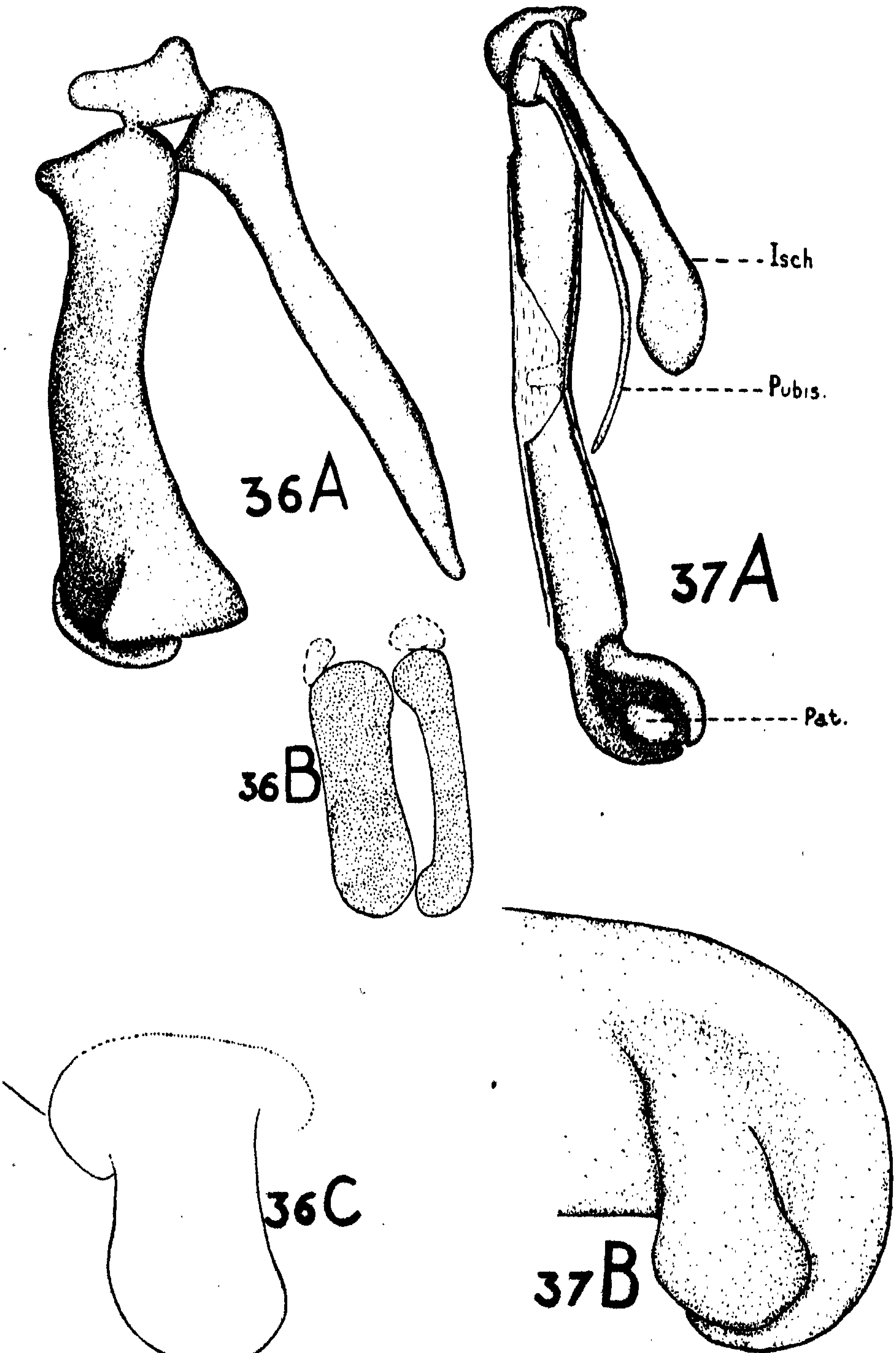


Fig. 36.—*a*. No. 47. × 12. *b*. No. 48. × 14. *c*. Fellow of donor to Nos. 47, 48.
Fig. 37.—*a*. No. 49. *b*. Fellow of donor to No. 49. × 8.

Whether, however, the proximal part of the graft is to be regarded as a radius and ulna, or as the two metacarpals of digits 2 and 3, depends upon whether the small structure marked with an asterisk is to be regarded as a toe or not. This I have not been able to determine. If we consider the two definitely known digits, we see that one consists of only one long cartilage and the other of three. Now, the middle digit of the normal wing has three phalanges, and the postaxial digit has but one. Thus we might regard these two digits as the middle and postaxial, in which case the proximal half of the graft must represent the metacarpals of these two digits, while the asterisk-marked structure must be denied digit rank, and the small carpal-like structure must be disregarded. On the other hand, if the proximal part of the graft be called the radius and ulna, then the larger of the digits must be the fused metacarpus and phalanges of digit 2; the right-hand digit must be metacarpus and phalanges of digit 3, while the small asterisk-marked structure becomes digit 1. Presumably, then, the swollen base of the large digit would represent its metacarpus which would then be sadly out of proportion with the metacarpus of digit 3. There are points in favour of, and against, both interpretations. Nevertheless, the important point remains that this is the distal part of a wing and the proximal part is absent. Notice especially that a considerable quantity of bone has developed on the concave side of the bent element in the proximal part of the graft.

No. 47. Figs. 36*a*, 36*c*.

Origin (Fig. 36*c*).—The basal third of the right anterior bud. The age of the bud is doubtful, but the stage of development it had attained is shown in the figure of the homologous bud.

Graft (Fig. 36*a*).—It consists of a humerus and part of the pectoral girdle. The girdle consists of an element like a scapula and a smaller fragment suggestive of a coracoid. The humerus has a somewhat expanded head, which is less developed than normally, while distally there are a pair of condyles, which, while not altogether normally formed, are yet clearly recognizable as such.

No. 48. Figs. 36*b*, 36*c*.

Origin (Fig. 36*c*).—The middle third of the same bud as for No. 47.

Graft (Fig. 36*b*).—It consists of a small radius and ulna, and of two small nodules of cartilage, one lying at the end (it is impossible to say which end) of the radius and the other at the same end of the ulna. These are probably the radiale and the ulnare.

No. 49. Figs. 37*a*, 37*b*.

Origin (Fig. 37*b*).—The basal third of the right posterior bud of a five-day donor.

Graft (Fig. 37*a*).—Femur, pubis, ischium, patella. The femur appears to have a head, but this is not absolutely certain, as the region supposed to bear the head is veiled by the proximal ends of the pubis and ischium. Distally, the femur widens out, and has evidently attempted, without great success, to form condyles. It has formed at this end a flattish expansion concave on one side. It is in this concavity that the patella lies. At the extreme proximal end of the femur is a small projection which certainly represents nothing normal to the femur, but may possibly be a tiny fragment of ilium. This is pure speculation. A certain amount of ossification has proceeded, and all but the extremities of the femur are surrounded by a thin layer of bone. Replacement of the cartilage has occurred in the central region.

No. 50. Figs. 38*a*-38*f*.

Origin (Fig. 38*f*).—The basal quarter of a left posterior bud of a five-day donor. The beginnings of toes are already detectable externally. In section it is seen that early cartilage is developed and the femoral, tibio-fibular, and foot regions are clearly distinguishable as continuous "scleroblastema".

Graft (Fig. 38*a*, *b*, *c*, *d*, *e*).—Considering its origin from only the basal quarter of the bud, the graft is a most remarkable structure. It consists of a femur, with, at the proximal end, a double piece of cartilage probably representing two pelvic elements. The femur has a head of sorts and ends in condyles which articulate

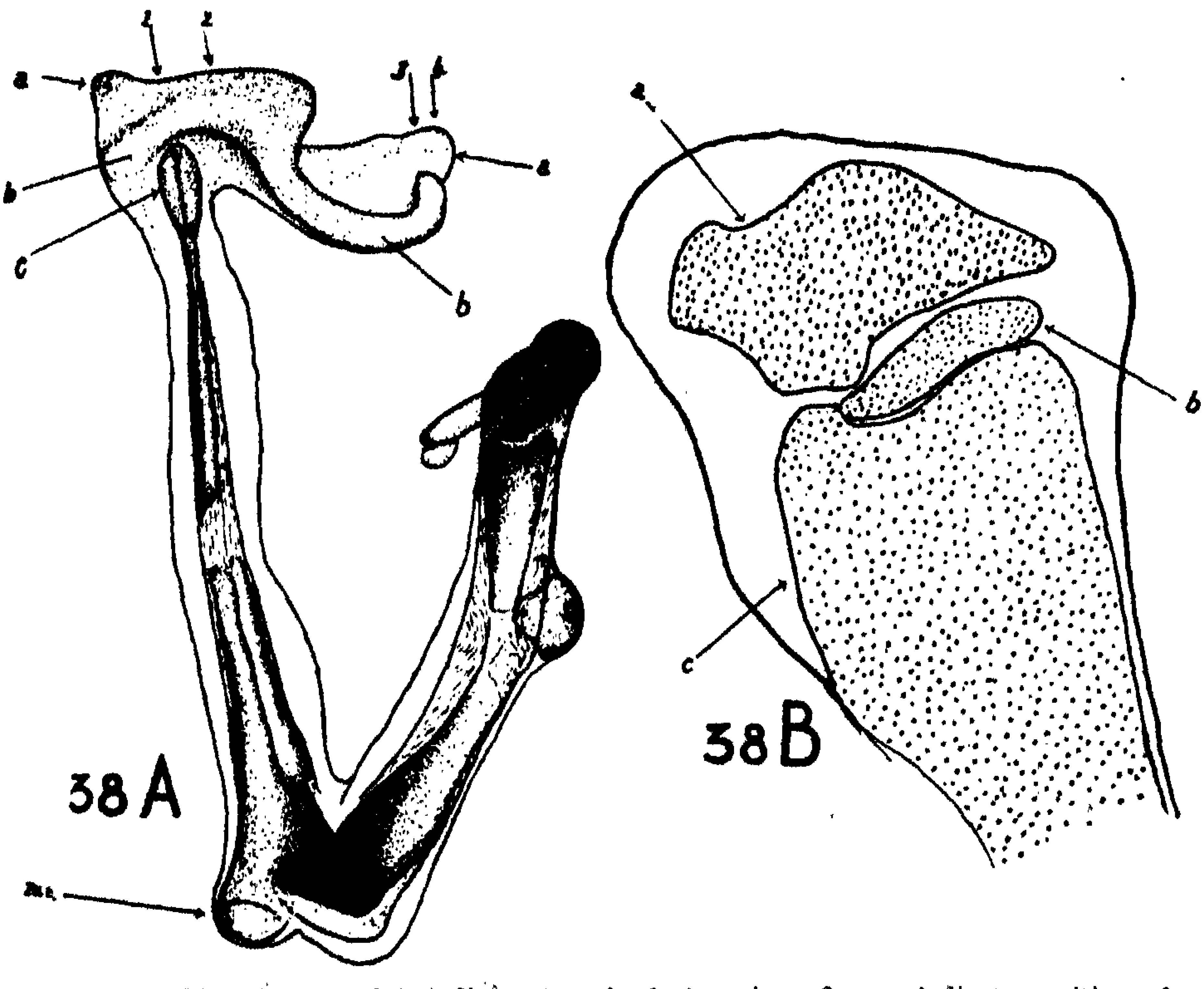


Fig. 38.—*a*. No. 50. *a* and *b* indicate toes in foot region; figures indicate position of sections shown in Figs. 38*b*-38*e*. *b*. Transverse section of foot region in position indicated by numeral 1.

with the proximal end of the tibio-fibula. In this region there is to be seen what seems to be a small discrete piece of cartilage, which probably represents the patella (*Pat*). Lying distal of the tibio-fibula is the curious structure appearing in Fig. 38*a*. The stain in this region was poor, and it was impossible in the cleared but unsectioned specimen to tell for certain just what this region contained, although it was fairly clear that there were two bars of cartilage, indicated by *a* and *b* in Fig. 38*a* and in Figs. 38*b*-*e* (sections). Examination of sections of this region shows that this surmise was correct. The arrows above the foot region in Fig. 38*a*, indicate the positions of the sections marked *b*, *c*, *d* and *e* respectively. A bar of cartilage runs from *a* in Fig. 38*a* at the left to *a* at the right and another one similarly from *b* at the left to *b* at the right. Both

these cartilages seem to be simple, unjointed rods. Despite its simplicity the positions of these two rods suggest very strongly that they are really an attempt to form a foot. The significance of this unique specimen will be discussed at a later stage. There is a marked difference in the degree of histological differentiation attained by the main bulk of this graft (femoral and tibio-fibular regions) and the foot region, the latter being much less advanced than the former. It will be seen from Fig. 38*a*, that considerable progress has been made in regard to ossification, considerable bone having been deposited round both femur and tibio-fibula. Notice that the deepest bone on the femur is on the concave side of the bend. About half-way along the length of the femur will be seen an appearance resembling a fracture. The real condition of affairs here has not been determined, nor has the nature of the curious pad of tissue on the convex side of the femur near the "fracture". The nature of the articulation between

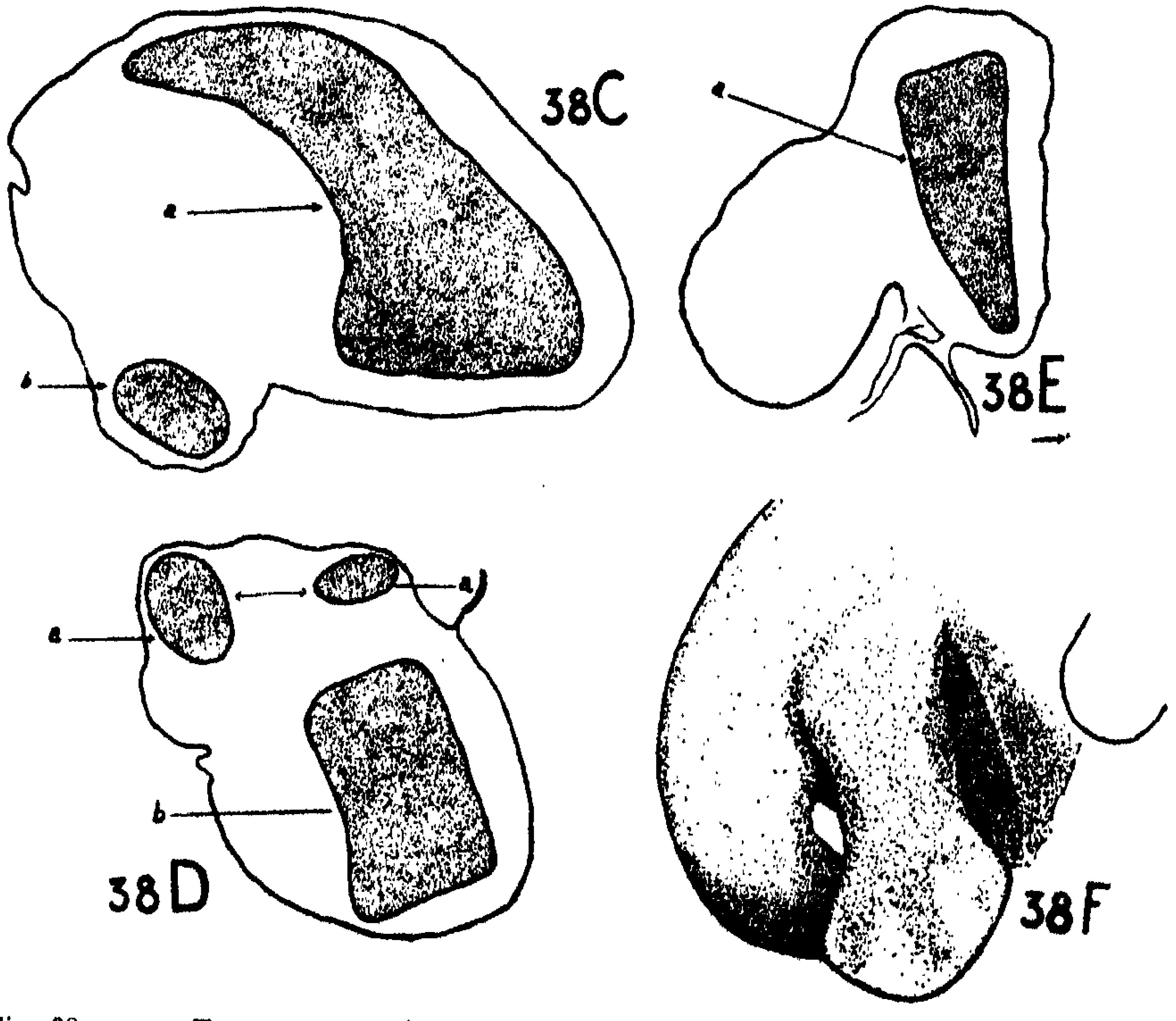


Fig. 38.—*c*—*e*. Transverse sections of foot region in positions indicated by numerals 2-4 in Fig. 38*a*. *f*. Fellow of donor to No. 50.

the tibia and the "foot" region is shown in section in Fig. 38*b*. Confusion will perhaps be caused by the fact that in Fig. 38*d* the cartilage "*a*" appears in two places. This is because this cartilage takes an upward turn in this region and hence is cut in two places in the same section.

No. 51. Fig. 39.

Origin.—The basal third of a posterior bud, side unknown, of a donor of unknown age, but probably five days.

Graft (Fig. 39).—Consists of the proximal region of the femur and part of the pelvis. The femur has well formed head, and indications at least of a trochanter. Distally, however, it ends in a blunt point, and the distal half is entirely wanting. The pelvis is difficult of interpretation; it must, in fact, be admitted that the only reason for calling the structures in question pelvis is that no other title seems to fit them better. The figure shows their general shape, and their arrangement in two distinct pieces. Beyond this it is perhaps wiser not to go. On the other hand, comparison with No. 19 suggests that this bifurcate "pelvis" structure may really be the proximal end of a tibio-fibula, fused proximally, incomplete distally, and altogether very abnormal in form. The abnormality is, of course, very obvious whichever interpretation be adopted.

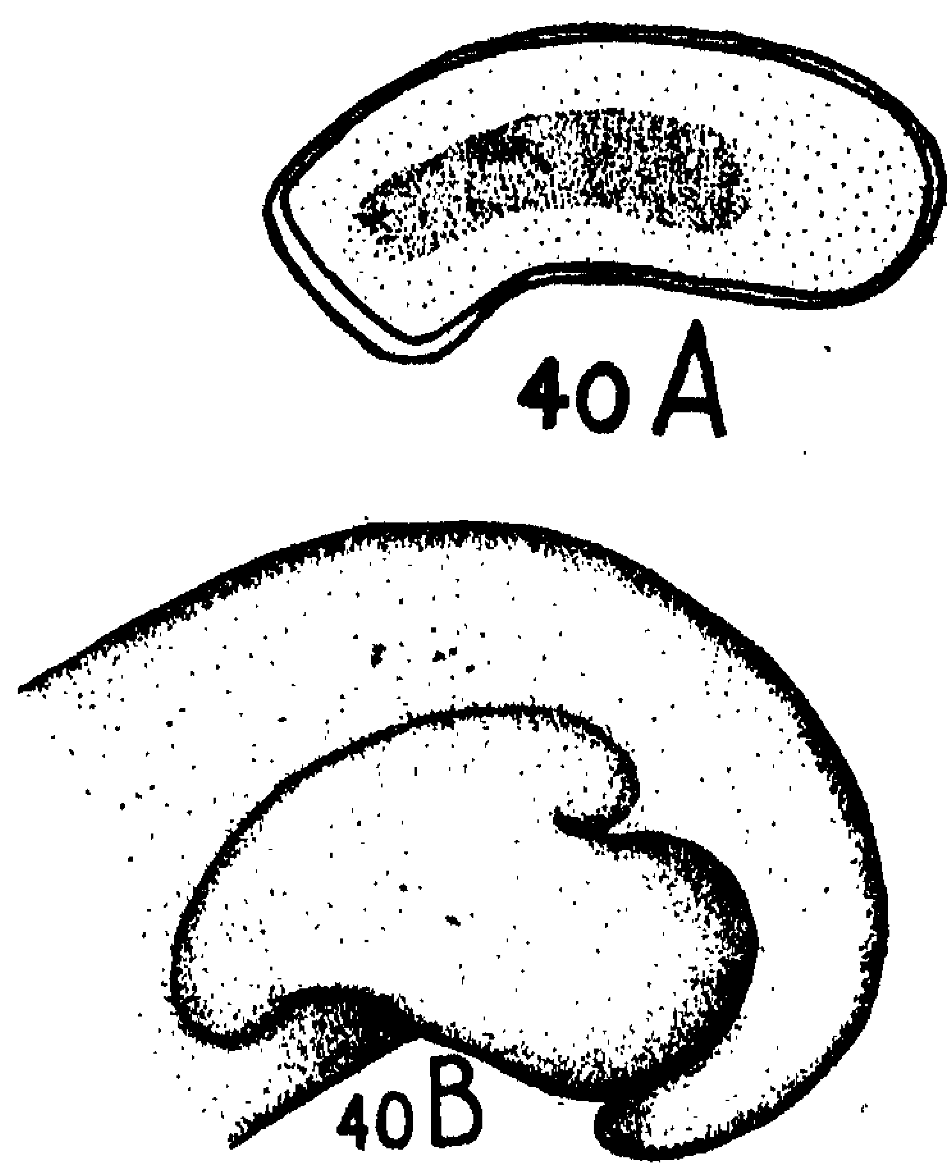


Fig. 39.—No. 51. × 9.
Fig. 40.—*a*. No. 52. *b*. Fellow of donor to No. 52.

No. 52. Figs. 40*a*, 40*b*.

Origin (Fig. 40*b*).—The basal third of the right posterior bud of a five-day donor.

Graft (Fig. 40*a*).—Consists of a small stout, slightly bent rod of cartilage which shows no morphological marks whatever, whereby it could be recognized as representing any particular part of the limb; nevertheless, its origin tells us that it can be no other than the femur, which has failed to develop beyond this condition.

No. 53. Figs. 41*a*, 41*b*.

Origin (Fig. 41*b*).—The apical third of the right posterior bud of a five-day donor.

Graft (Fig. 41*a*).—A complete foot, and three tarsal elements. Metatarsals 2 and 3 are fused together, but 1 and 4 have maintained their independence, at least partly. Digit 1 is shown in light stipple because, the stain being bad here, it is difficult to detect its exact outlines.

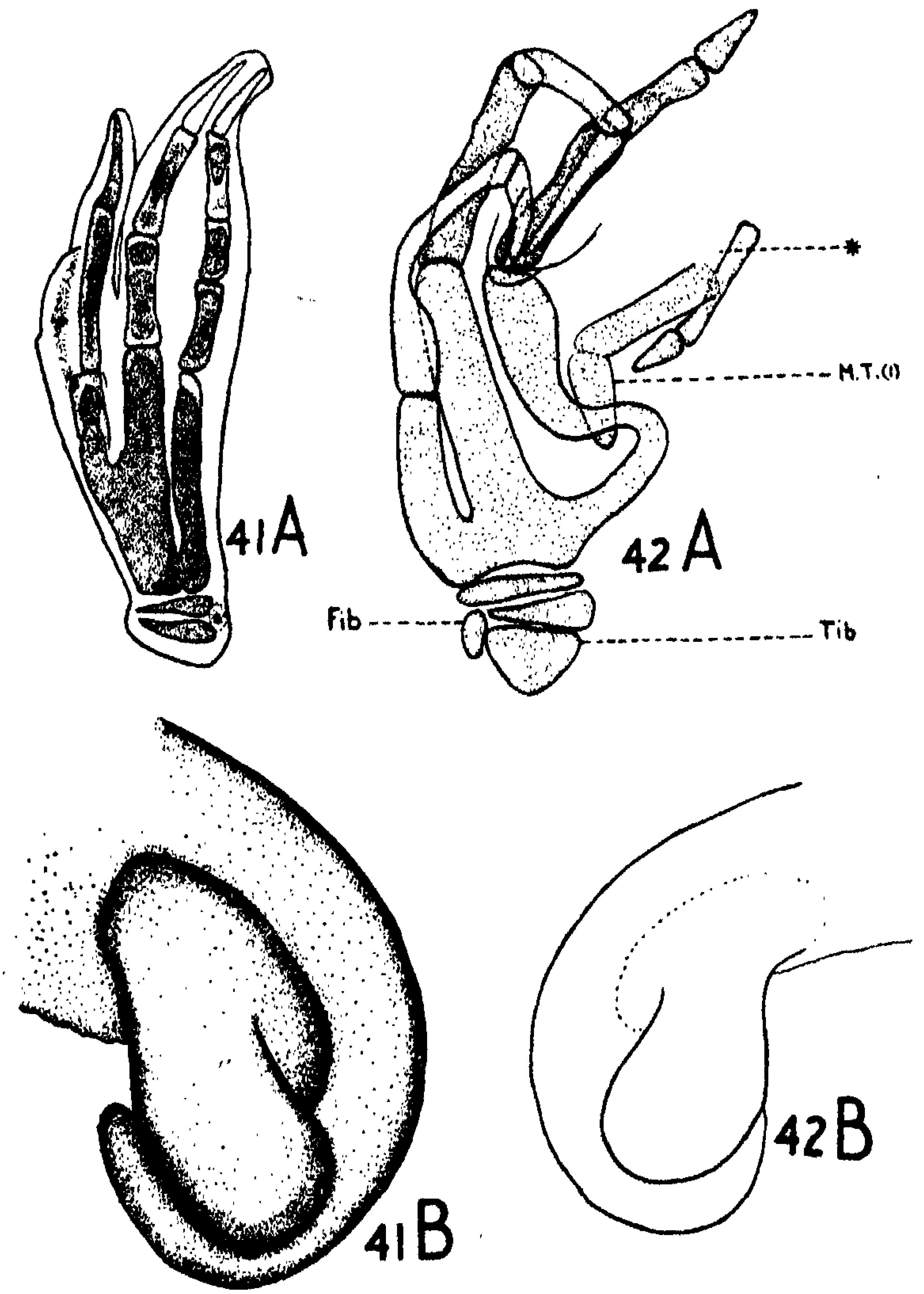


Fig. 41.—*a*. No. 53. × 5. *b*. Fellow of donor to No. 53.
Fig. 42.—*a*. No. 54. × 7. *Tib*, tibia; *Fib*, fibula; *M.T.*1, metatarsal 1. Asterisk explained in text. *b*. Fellow of donor to No. 54. × 7.

No. 54. Figs. 42*a*, 42*b*.

Origin (Fig. 42*b*).—The apical third of the left posterior bud of a five-day donor.

Graft (Fig. 42*a*).—A complete foot, with (probably) the distal ends of the tibia and fibula. The two latter are probably present as two nodules of cartilage,

and distal to them lie two tarsal bones. Next come the three metatarsals 2, 3 and 4, fused at their bases, but free along nearly the whole of their length. Metatarsal 1 lies to the right of 2 and is quite a short element. The digits and their phalanges are, as shown in the figure, considerably distorted and bent over. In the case of the first digit, the asterisk marks a position where another cartilage, poorly stained, and of doubtful existence, may lie between the second and third phalanges. The differences in density of stippling have been introduced purely to distinguish the different phalanges from one another, in places where one lies above another.

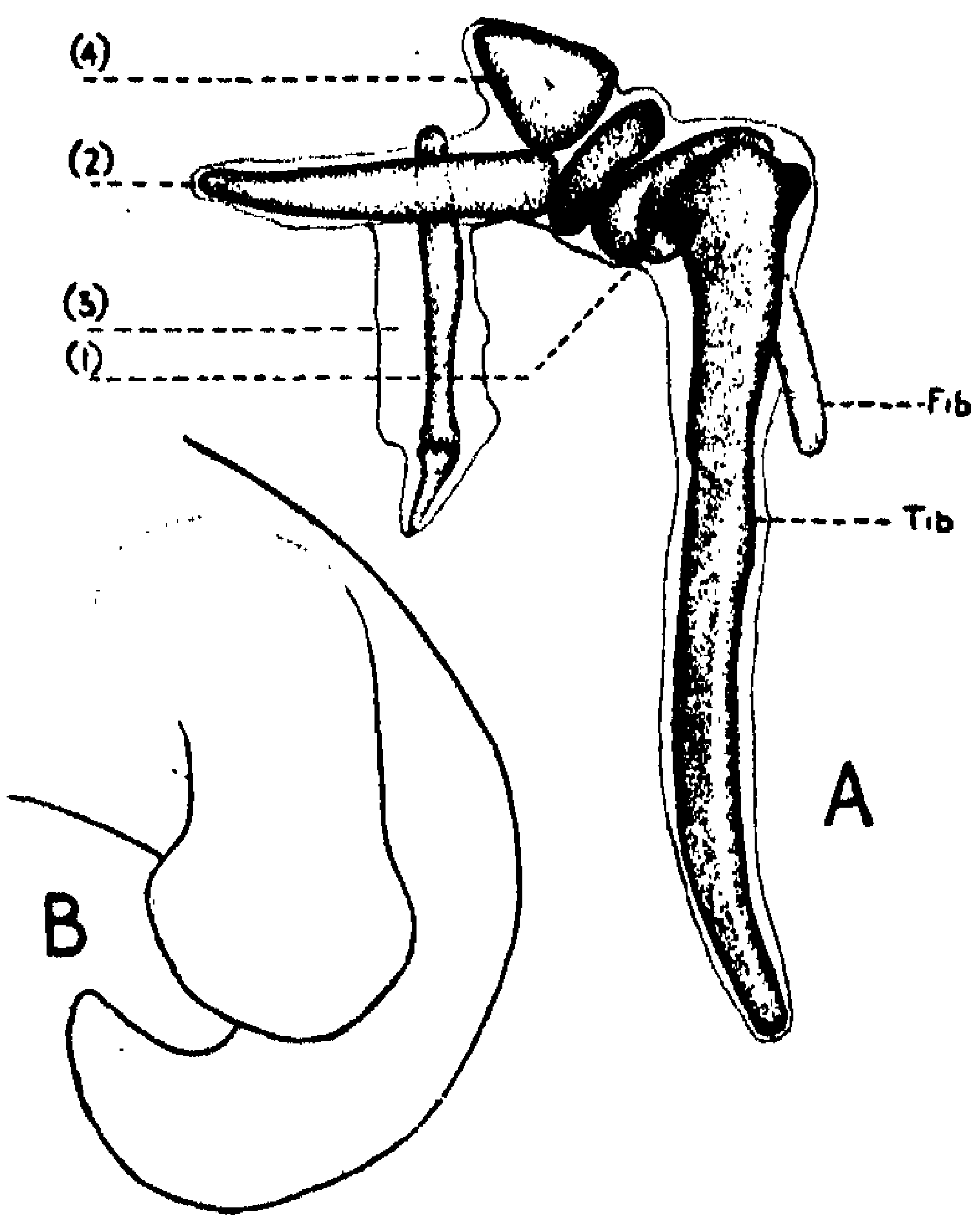


Fig. 43.—*a*. No. 55. × 7. Numerals indicate serial numbers of digits. *b*. Fellow of donor to No. 55. × 7.

No. 55. Figs. 43*a*, 43*b*.

Origin (Fig. 43*b*).—The middle third of the right posterior bud of a five-day donor.

Graft (Fig. 43*a*).—It consists of an incomplete tibia and fibula, of two tarsals and four or three toes. The tibia and fibula are complete at their distal ends, but end incompletely proximally. The first toe is a single nodule of cartilage, the second is a single rod, the third, pointing proximally, has been so bent round as to lie parallel to the tibia. Only the third, which has two, has more than one element in the toe. All the others have but a single rod of cartilage representing both metatarsal and phalanges. The fourth is a short, thick and pointed nodule of cartilage.

No. 56. Figs. 44*a*, 44*b*, 44*c*.

Origin (Fig. 44*c*).—The basal third of the left anterior bud of a five-day donor.

Graft (Figs. 44*a*, 44*b*).—It is a humerus and two pieces of pectoral girdle. The humerus has a fairly well formed proximal end, but distally is incomplete, or at any rate has failed to form anything like a joint structure. It is difficult to identify the girdle elements with any degree of certainty but, from its general form, that marked *Scap* is probably the scapula, and the smaller piece probably a fragment of coracoid. The form of the expanded head and of the girdle elements is shown to better advantage in Fig. 44*b*.

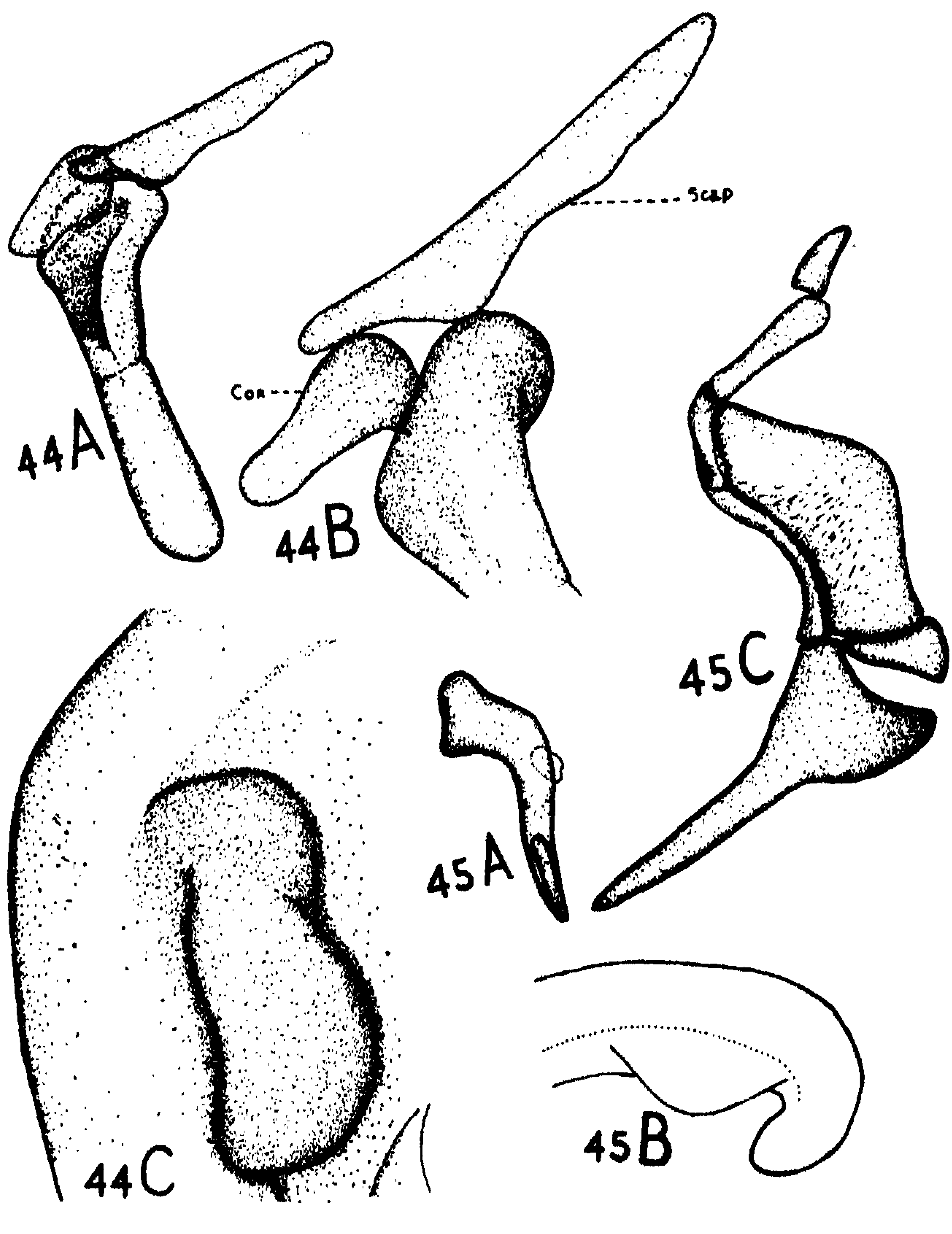


Fig. 44.—*a*. No. 56. *b*. Head region of No. 56. *Cor*, coracoid; *Scap*, scapula. *c*. Fellow of donor to No. 56.

Fig. 45.—*a*. No. 57. × 8. *b*. Fellow of donor to Nos. 57, 58. × 7. *c*. No. 58.

No. 57. Figs. 45*a*, 45*b*.

Origin (Fig. 45*b*).—The basal half of the right posterior bud of a three-day donor.

Graft (Fig. 45*a*).—The graft consists of a small rod of cartilage, curved, expanded at one end and having a certain very remote resemblance to the proximal end of a femur, and at the other end culminating in a point. There is also a small nodule of cartilage lying beside the rod about half-way down its length.

No. 58. Figs. 45*b*, 45*c*.

Origin (Fig. 45*b*).—The apical half of the same bud as for No. 57.

Graft (Fig. 45*c*).—The graft is a curious structure. It appears to consist of the distal end of a femur, a patella, a tibia and a fibula and one toe with a metatarsal and two phalanges. Some ossification has occurred on the element which I call the tibia, chiefly because it is so much larger than its fellow, which thus becomes the fibula. It should be noted that the femur is incomplete proximally, ending in a point. The incompleteness of the foot must be due to the abnormal conditions, since the whole foot anlage was present in the graft.

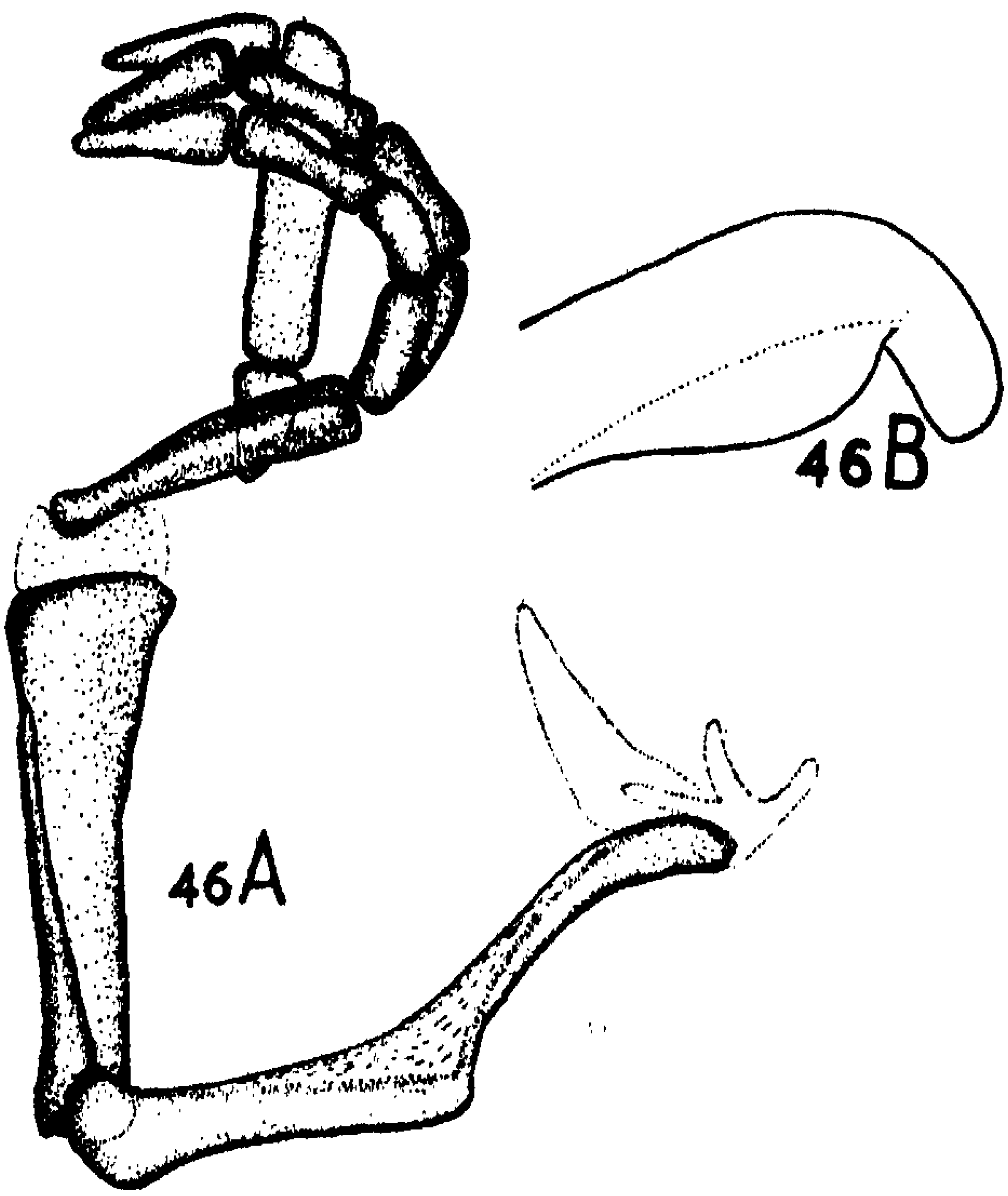


Fig. 46.—*a*. No. 59. × 5. *b*. Fellow of donor to No. 59. × 7.

No. 59. Figs. 46*a*, 46*b*.

Origin (Fig. 46*b*).—Half of the right posterior bud of a three-day donor. It is not known for certain from which half it comes.

Graft (Fig. 46*a*).—The graft is a large structure, and is a nearly complete leg. Proximally there are certain poorly stained structures, evidently belonging

to the pelvis, which in the figure have been indicated in outline only. The femur lacks head and trochanter and has the general appearance of being incomplete longitudinally in its proximal half. Its distal half seems to be fairly complete. It is doubtful to what extent condyles have developed. There is a large tibia, a fibula which ends in a point distally, and three toes, the metatarsals of two of which are fused together to form a flat plate whose edge is facing the observer. The tarsals are represented by what seems to be a single poorly stained cartilage between the tibia and the metatarsals. Ossification has occurred in the femur, predominantly on the concave side, as usual.

Grafts of fragments of two-day embryos.

No. 60. Fig. 47.

Origin.—Donor: 25 somites, 2 days. The graft was a section right across the entire embryo, including the region containing somites 11 to 20.

Graft (Fig. 47).—The graft attained to a high stage of differentiation of spinal cord, vertebrae, etc., but we are at present only interested in the limbs. Sections of the graft show beyond doubt the existence of two limbs. Fig. 47 represents part of the section containing spinal cord and a vertebra cut approximately in T.S. with, dorsally and to the right, part of one of the limbs. The differentiation

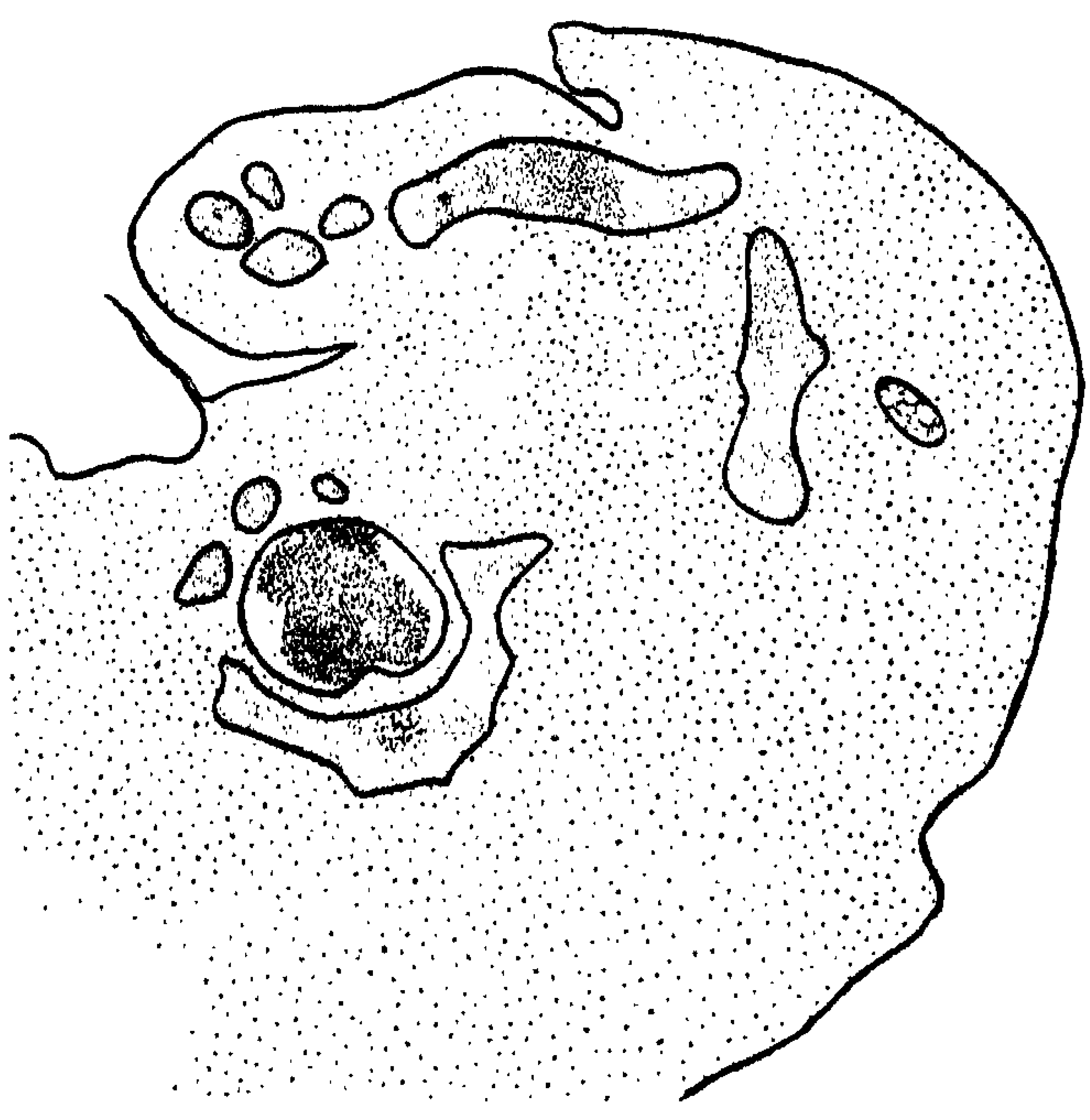


Fig. 47.—No. 60. Transverse section.

of the cartilage is well advanced, and the different parts of the limb are segmented off from one another. In the absence of any fixed point by the use of which reliable reconstructions could be made, in view of the complexity of the object, and in view, also, of the fact that the theoretical conclusions to be drawn

from this specimen can really be deduced with greater force from others, the detailed anatomy of the limb has not been studied. It is, of course, a very abnormal structure. Its distal regions are much cramped and small, hence the separation from one another of individual digits is very difficult.

No. 61. Fig. 48*a-e*.

Origin.—Donor: 23 somites, 2 days. The graft consisted of the posterior end from somite 20 to the end of the embryo.

Graft (Fig. 48*a-e*).—The graft was a large structure (Fig. 48*a*) and from one end could be seen projecting two toes of a limb. There were also a number of feather germs, as shown in Figure 48*a*, and in section in Fig. 48*e*. On clearing, the appearance was as shown in Fig. 48*a*. The limb appeared as a single long shaft of cartilage with, distally, two toes, each of two segments. Proximally, it could be seen that the shaft of the limb turned downwards into the centre of the whole graft, and was there lost to view. Sections were cut in a plane approximately transverse to the main shaft of the limb, the lettered arrows shown on Fig. 48*a* indicating roughly the positions of the similarly lettered sections. Fig. 48*e* shows that sections confirm the existence of two toes. Following the sections, we find that proximal to the two toes is a single shaft of cartilage (Fig. 48*d*). Continuing, we come to a region where the shaft is double again, shown in Fig. 48*c*. There is thus an error in Fig. 48*a*, which represents this region as containing a single shaft of cartilage, like more distal regions. This error has not been corrected as the figure was an accurate record of what could be seen in the cleared specimen. Following the sections further in the proximal direction, we

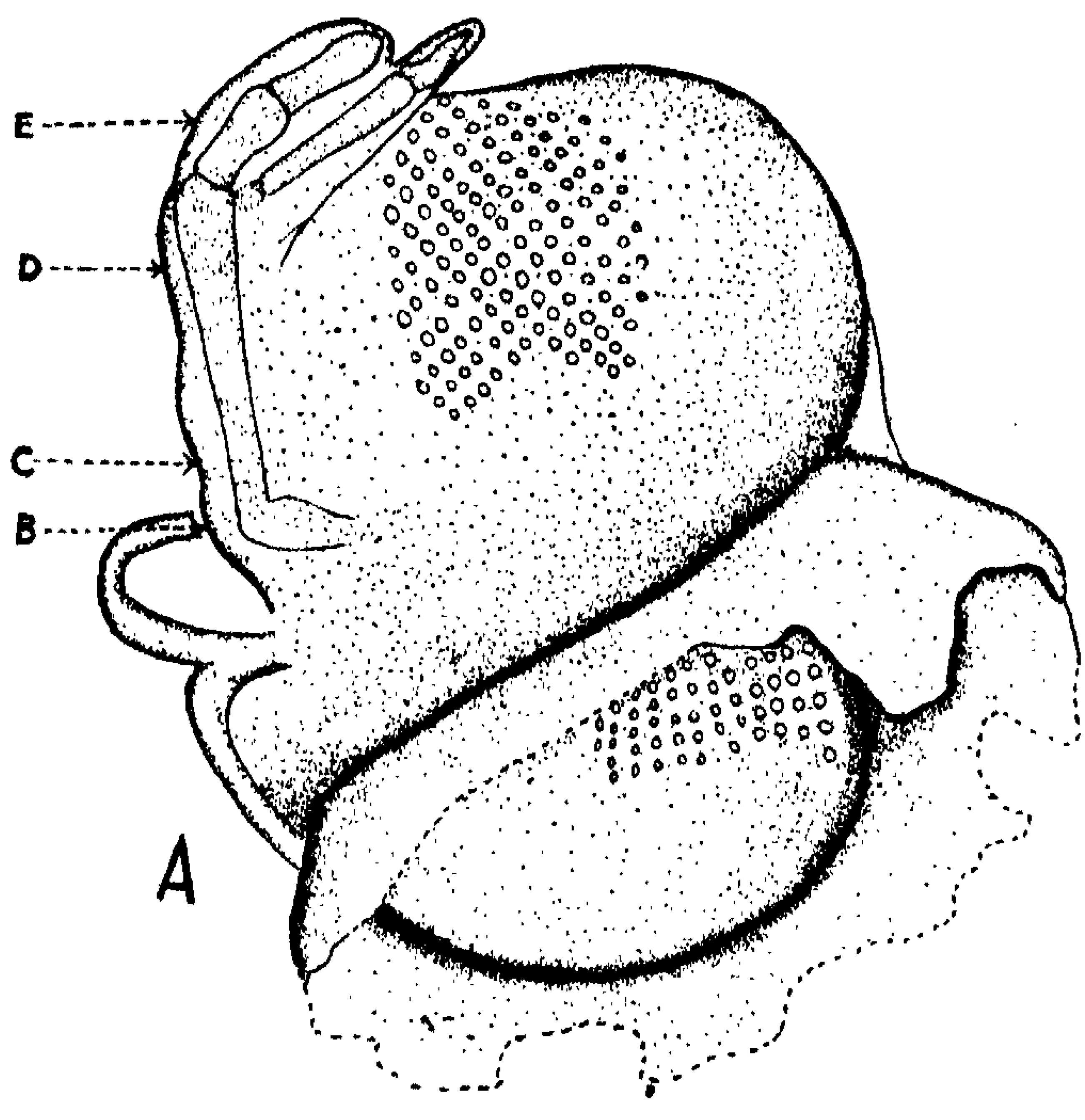


Fig. 48*a*.—No. 61. Entire cleared object. The letters B-E indicate positions of sections in Figs. 48*b-e*.

come to the point where the main axis of the limb turns inwards to the centre of the graft. Here (Fig. 48*b*) we find the double condition disappears again, and a much stouter cartilage runs inwards to the centre.

We thus have a limb consisting proximally of a stout cartilage, doubtless the femur, next a pair of cartilages, tibia and fibula, then a single shaft which may be either the distal end of the tibia or the fused metatarsals of the two digits, and

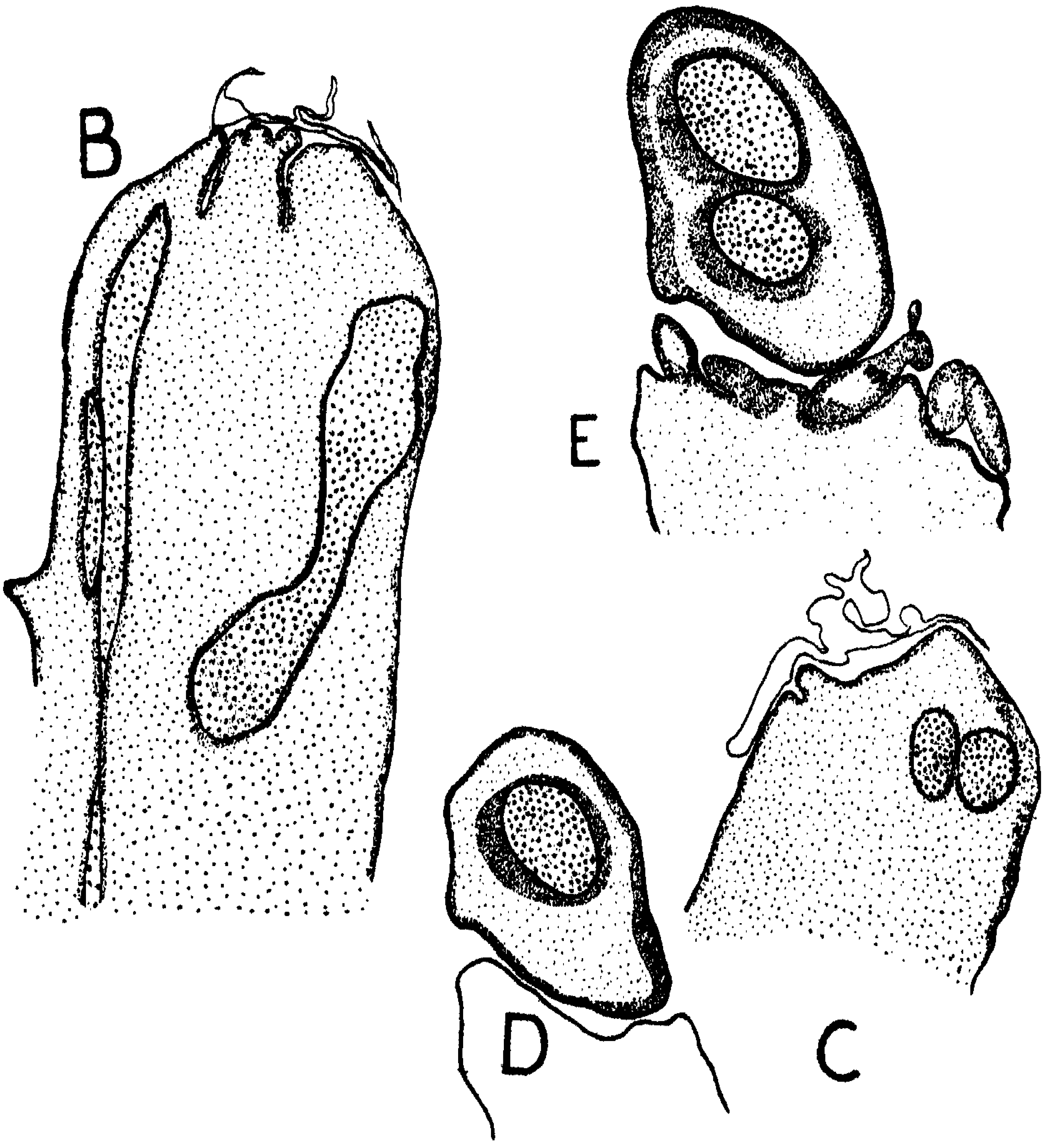


Fig. 48.—*b-e*. Sections of No. 61 at points indicated by letters B-E in Fig. 48*a*.

then the two digits themselves. In examining the sections about the region indicated in Fig. 48*a* by the arrow *B*, where the main axis of the limb turns, and the tibio-fibular region has its proximal end, it appears that, of the two rods forming this region, one is a direct continuation from the femur, and is probably

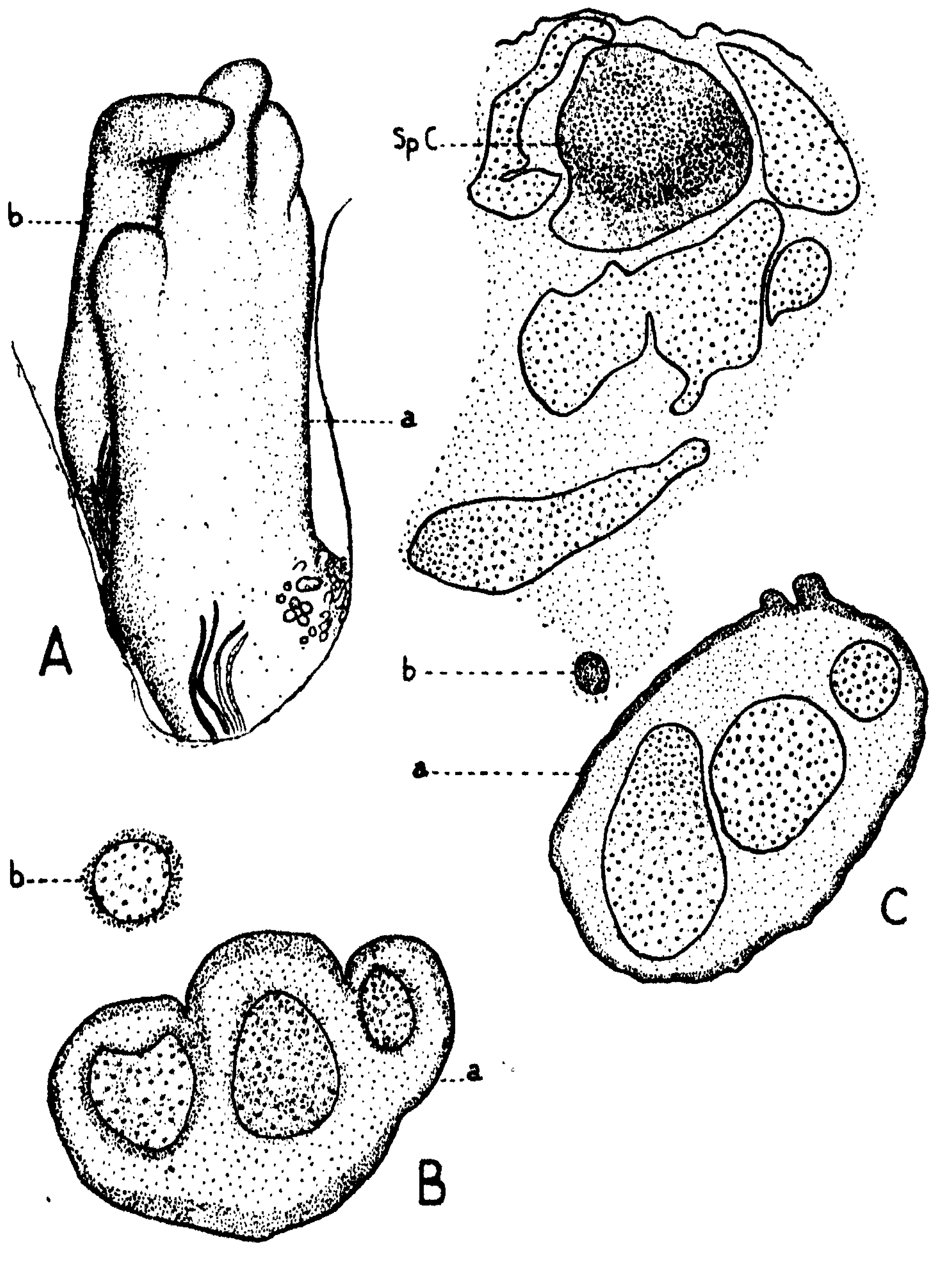


Fig. 49.—*a*. No. 62. Part of whole (uncleared) graft to show limb-like structures, a and b. *b*, *c*. Sections across limb structures a and b. *Sp. c.*, spinal cord. Section *b* is the most distal; Figs. 49*c*-49*g* are progressively more proximal.

directly continued as the single cartilage distal to the tibio-fibular region, while the other element of the tibio-fibular region cuts in and then cuts out again, without undergoing any fusion at all. Distal to this region the two digits are found to be independent of (i.e., not fused with) the single rod proximal to them.

The other limb of this specimen has not developed in such a way as to be recognizable in the sections, while it was invisible in the whole cleared specimen. A number of other cartilaginous rods, etc., are present in the interior of the graft, but, as it is sufficient for my present purposes to demonstrate the existence of a limb, the difficult task of discovering their form and relationships has not been attempted. Probably they belong partly to the pelvic girdle of the limb here described, and partly to its more or less aborted fellow. Some of these cartilages appear to the left in Fig. 48*b*. In suitable sections the spinal cord and vertebrae can be seen.

No. 62. Figs. 49*a*-*g*.

Origin.—Donor: 26 somites, 2 days. The graft consisted of a section across the entire embryo comprising from somite 23 to the end of the embryo.

Graft (Figs. 49*a*-*g*).—The graft, when seen as a whole uncleared specimen, showed distinctly what seemed to be a pair of limbs. These are shown in Fig. 49*a* which represents only this region of the graft, not the entire graft. Of these two limbs one (Fig. 49*a*, *a*) seemed to consist of three toes and one (Fig. 49*a*, *b*) of one toe. The cleared specimen confirmed this, to the extent of showing each of these toes to consist of a segmented rod of cartilage. Sections were cut in a plane at right angles to the long axis of these limbs. Fig. 49*b* shows a section of these two "limbs" at a point well away from the main part of the graft. The section consists of two parts, one through the three-toed structure, showing three rods of cartilage cut in T.S., the other through the one-toed structure showing one rod. Fig. 49*c* shows a section where the "limbs" join the main body of the graft. So far as the limbs are concerned, the structure is essentially the same as in Fig. 49*b*, except that *b* has become very small and shortly after cuts out and disappears altogether. Dorsally we se, a section (oblique) of the spinal cord and of a vertebra. The other cartilage between the vertebra and the limbs need not concern us. In Fig. 49*d*, still further proximally, we still see the oblique section of the spinal cord and vertebrae, and below them we see (*a*), now consisting of only two cartilages, the one on the right having fused with the central one (almost certainly). In Fig. 49*e*, still further proximally, a change has begun. *In previous sections a cartilage arises to the right of the other two.* Ultimately it stretches round the central one (previously the one to the right), practically surrounds it, and fuses with the one on the left, as shown in the sections. The spinal cord and parts of the vertebrae, now cut very obliquely, can be seen above. In Fig. 49*f*, still further on in the same direction in the series, we see that the old cartilage, originally the right one of the pair shown in Fig. 49*a*, has nearly cut out *and shortly after this section does so completely.* A long cartilage, bifurcated above, now lies above the limb structure, and is perhaps an attempt at some pelvic girdle element. In Fig. 49*g* this girdle structure is shown present in several pieces, while in the limb region proper a new cartilage altogether has arisen, just above and contiguous to the old one, so we now have a double structure again. Soon, however, both these cartilages cut out altogether. Two things will be obvious from this description; (*a*) that this graft made a vigorous attempt to develop at least one limb, (*b*) that this attempt resulted in the appearance of a

structure which, while clearly very far from normal, is nevertheless clearly at least one limb. Since the two structures, the one with three toes and the other with *one, run separate from one another for their whole course, it* seems best to regard them as each being an attempt to form a limb, rather than as both being parts of the same limb. Nevertheless, it is, of course, quite impossible to settle which of these two alternatives is really correct. Against the hypothesis that they are separate limbs is the fact that both issue from the graft on the same side. This, however, may very well be only an apparent objection, for in following the section in a proximal direction, the two cut out at very different

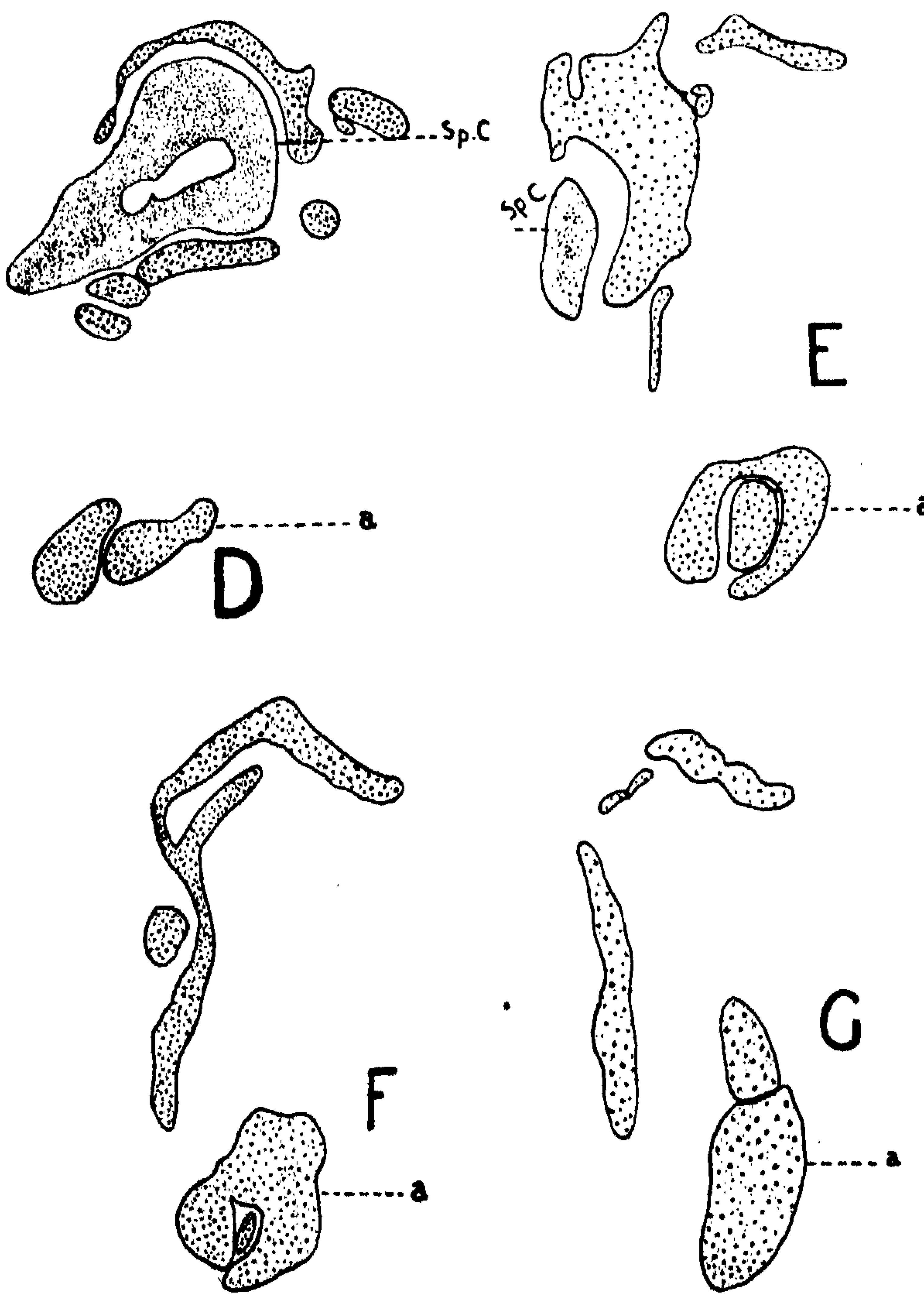


Fig. 49.—*d-g*. Sections across limb structures, a and b of Fig. 49*a*.

places, one quite soon after the sections enter the main body of the graft, and one long after. So it is perfectly possible that they really have their proximal ends on morphologically different sides. The extremely twisted condition of the axial structures (spinal cord, etc.) renders it impossible to decide this point. As regards the limb or limbs themselves, any attempt to identify femur, tibia, fibula, etc., would be nearly hopeless. It is clear that those regions of the structures, where they project out from the body of the graft, constitute a foot or feet region, and consequently that the more proximal regions must be the tibio-fibular and femoral regions. Perhaps the single cartilage shown in Fig. 49*f* and also in 49*g* may be said to represent the femur, while the double region in Fig. 49*d* may be the tibio-fibula, and more distal regions the foot.

No. 63. Fig. 50.

Origin.—Donor: 22 somites, 2 days. The graft was obtained by making a cut through the thirteenth somite, in as far as the spinal cord, and similarly between the 22nd and 23rd somites, and another cut longitudinally between the

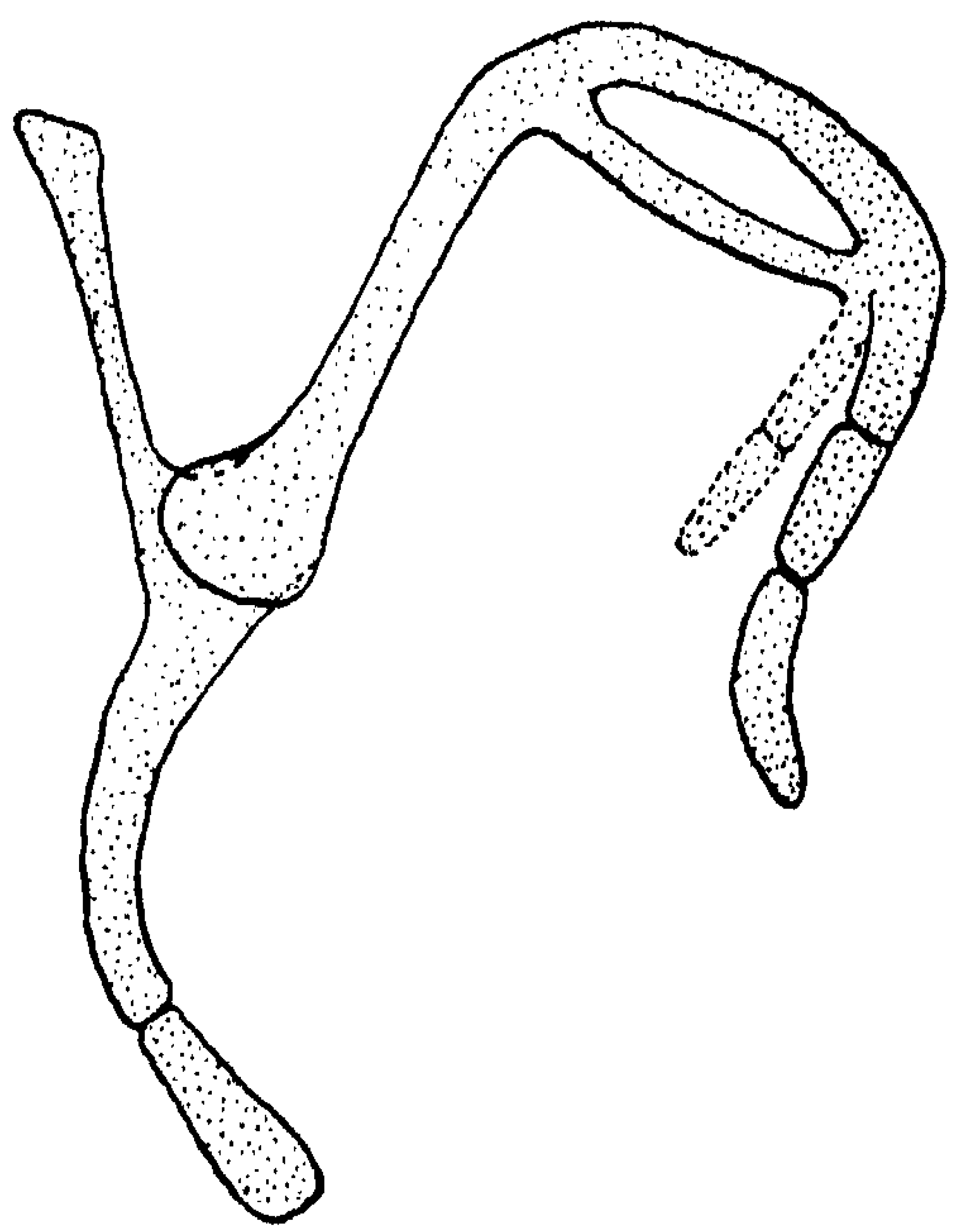


Fig. 50.—No. 63. Very diagrammatic, from cleared specimen and from sections.

somites and the spinal cord, joining up the two previous cuts. Thus the graft contains somites 14 to 22 and structures lateral to them on one side, for some distance out into the area pellucida, but no axial structures, nor any other structures anterior to somite 13 or posterior to somite 22.

Graft (Fig. 50).—The entire object showed clearly that there was a limb present. Fig. 50 is constructed very diagrammatically from data obtained from the entire cleared object, and from sections. There are two digits, of which one has at least two phalanges and the other probably at least one. There may be other digits as well as these, but I believe not. Proximal to the digits comes the region shown in the figure where two cartilages lie side by side, fused at their

ends. It seems but reasonable to regard these two cartilages as the radius and ulna, but it would be a thankless task to try to decide which is which. Proximal to this region is a single curved cartilage which must be the humerus. This fuses proximally with two other cartilages, one of which is jointed at its end, and which can only be regarded as hopelessly abnormal pectoral girdle elements. In spite of the doubt in this specimen, as in others from fragments of two-day chicks, as to the identity of special parts of the graft, there can be no question whatever that a limb has here been developed.

No. 64. Fig. 51.

Origin.—Donor: 23 somites, two days. The graft was obtained in a manner similar to that in which No. 63 was obtained, but the region taken from the donor was further posterior, in the region where somites were not yet developed. The graft thus consisted of tissues about to segment into somites, but which had not yet done so, from just behind the last somite to just anterior to the level of what was left of the primitive streak, without any axial organs and without the posterior end of the chick, and of more lateral tissues in the area pellucida.

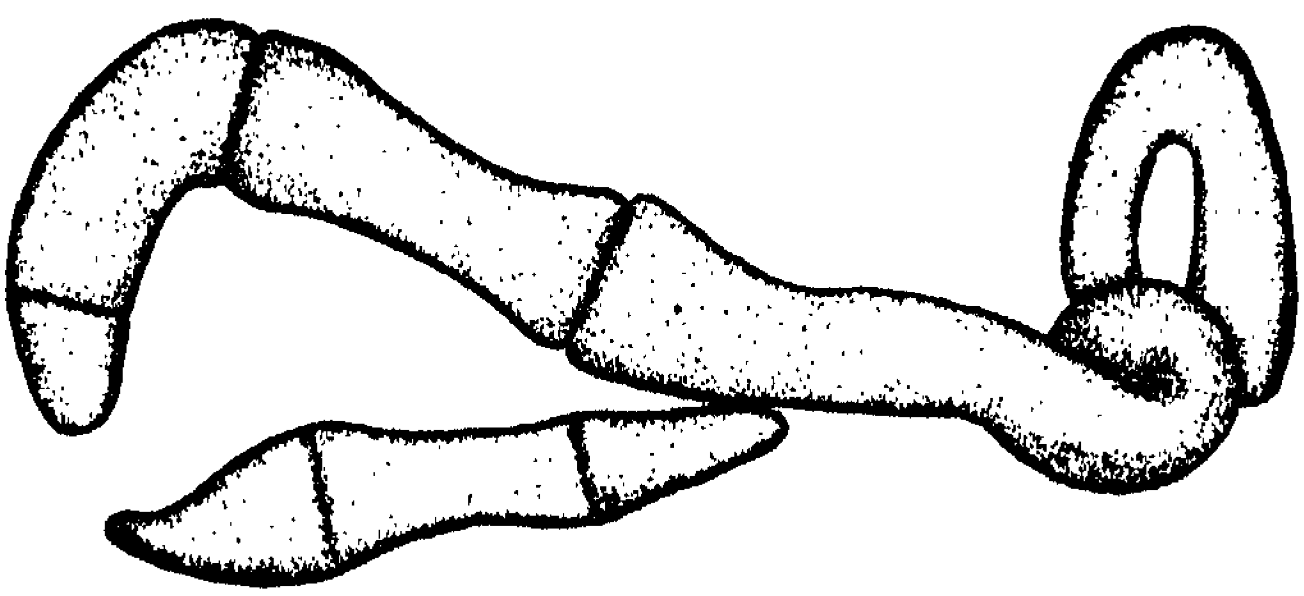


Fig. 51.—No. 64.

Graft (Fig. 51).—The graft consists of a cartilaginous structure, which is manifestly an attempt at a limb. Fig. 51 describes it more successfully than any words. It would appear to consist of two toes and of a single axial rod which, at the proximal end, bends downwards in a curve. The U-shaped structure lying beneath this down-turned region of the main rod is really a complete loop of cartilage, not in direct connection with the main rod. Sections confirm this description.

No. 65. Fig. 52.

Origin.—Donor: 23 somites, two days. The graft consisted of a piece precisely like that used in No. 64, i.e. pre-somitic and more lateral tissues only.

Graft (Fig. 52).—The graft is in two distinct parts. The one is a finger-like rod of cartilage, divided into three segments. The other is a curved rod of cartilage not in direct connection with the segmented rod, lying as shown in the figure, with, at one end, a shorter rod of cartilage lying beside it. No one could contend that this is a complete limb, but it is undeniable that here we have a structure consisting, like a limb, of bars of cartilage, some of them segmented, and so we can come to no other conclusion than that here again we have an attempt to form a limb. It should be pointed out here that, running between the angle of the curved bar of cartilage and a point near one end of the finger-like rod, is a bundle, or rather two bundles, of definitely recognizable embryonic muscle.

No. 66. Fig. 53.

Origin.—Donor: 23 or 24 somites, two days. The graft was of precisely the same character as those used in Nos. 64 and 65, i.e., the graft contained tissues about to become somites, tissues lateral to these, but no axial organs and no

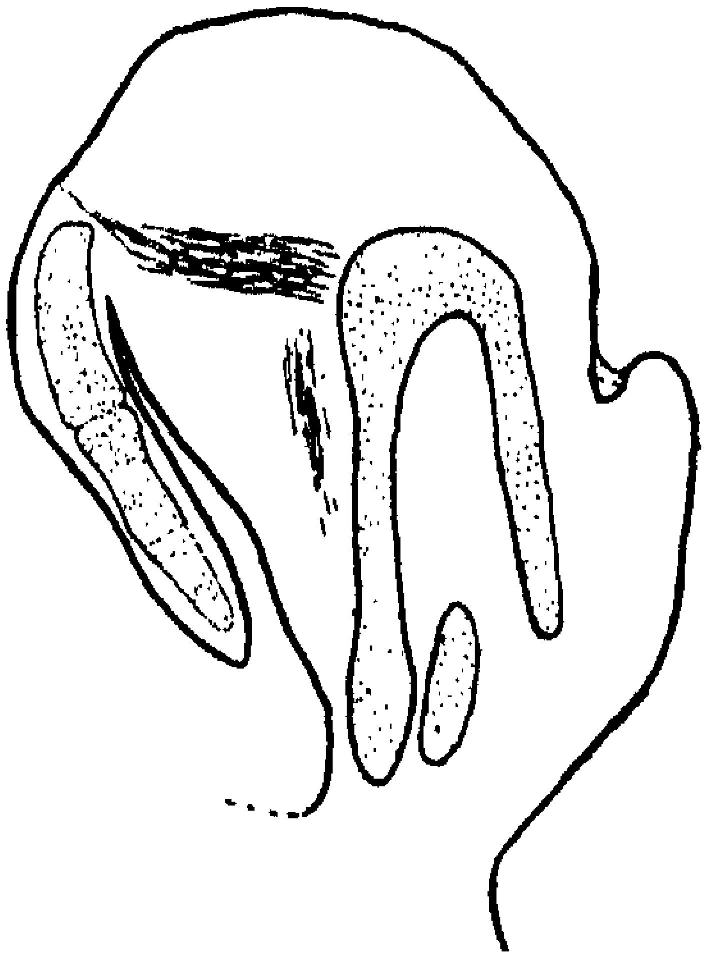


Fig. 52.—No. 65.

tissues at all anterior to the region where somites are not yet developed nor posterior to a level just anterior to what is left of the primitive streak.

Graft (*Fig.* 53).—The graft is a very simple structure. It consists simply of a small bifurcated mass of cartilage.

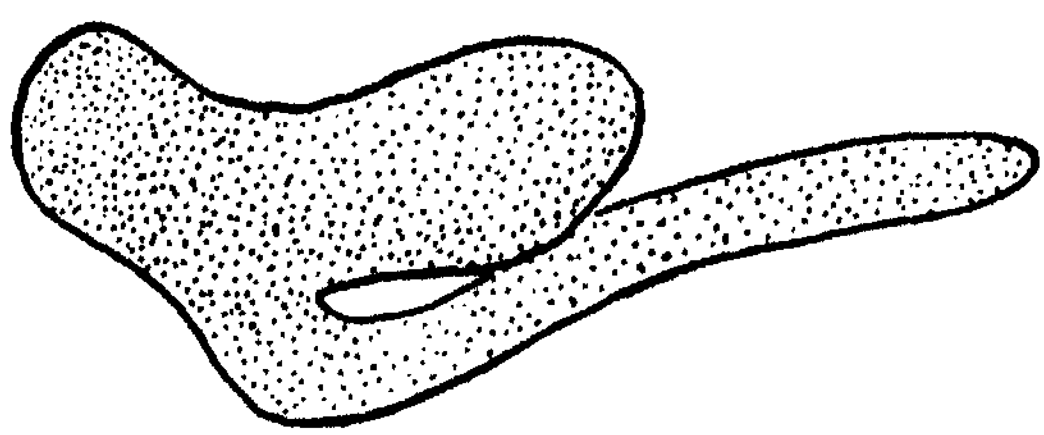


Fig. 53.—No. 66.

Discussion.

Self-Differentiation.

This term is one which has been curiously open to misinterpretation. Carey (1921), for instance, refers to "some unknown non-biological method of self-differentiation" and asserts that if self-differentiation be accepted as a process in development, then "the solution of the problem of the development of the limb goes by default", whatever that may mean. Such statements seem to reveal a failure to understand the meaning of the term, or else a dialectic stretching of the term to limits never intended by those who believe in the reality of the process

it denotes. The processes involved in self-differentiation are no more "unknown", or "non-biological", than are the processes assumed by Carey (without experimental justification) in his system of "dynamics of histogenesis" in the limb. It is true that the mechanism of self-differentiation is unknown, but it is equally true that we do not know the mechanism whereby a region of mesenchyme subjected to "optimum tension" takes on the form of striated muscle (according to Carey). Why self-differentiation should be marked with the stigma "non-biological" I must admit myself completely unable to understand.

Self-differentiation simply means the process wherein a part of an embryo develops from an earlier to a later stage, without receiving from the remainder of the embryo any "formative stimuli", or any other assistance beyond a supply of food, oxygen, warmth, isotonic medium, etc. Put more positively, the self-differentiating region is thought of as developing "under its own steam", so to speak, not as being directed by other parts of the embryo. Dependent differentiation, on the other hand, is the opposite of this, as when we find the lens of the eye failing to develop in the absence of the optic cup.

In the last resort, it is probable that all differentiation in the vertebrate embryo is dependent. The work of Spemann (1924) and his school has shown conclusively that the formation of the main axis itself of the embryo Urodele is dependent for its appearance on the dorsal lip of the blastopore, or rather on the ento-mesoderm therein contained. Brachet (1923) has extended this conclusion to apply to the Anura. While it has not been shown that the same is the case in other groups, it would seem at least highly probable that it will be found to be true for them also, since, considering the fundamental uniformity of structure in the vertebrate phylum, one expects similar uniformity in the processes whereby that form is attained. Even if it be the case that all development is ultimately dependent on an "organiser of the first grade" (Spemann), we do not need to abandon belief in self-differentiation of organs. The function of the organizer system is *determination*, not differentiation; that is, the organizers decide into what organ of the adult particular parts of the embryo are to develop, at the same time restricting the potencies of those parts. This has been shown very beautifully by the work of Spemann and of Mangold (1924). The latter worker found, using a technique which need not be described here, that presumptive ectoderm cells taken from an embryo *Triton* which had attained a certain stage could, if grafted among the mesodermal cells of another embryo, be induced to form mesodermal structures like somites, etc., but that precisely similar presumptive ectodermal cells, taken from an embryo at a slightly later stage (about close of gastrulation) and treated in a precisely similar manner, developed, not into mesodermal structures, but into ectodermal structures. Thus the ectoderm, which up to a certain stage still retains the potency to form organs usually originating exclusively from cells of another germ layer, after that stage has completely lost this power and can then form nothing but ectodermal structures. In other words, the stage of determination has been passed. Thus the "determined" ectoderm cells, placed in an environment which would have caused them to join in the formation of mesodermal structures had they been placed there a little earlier in their history, now self-differentiate and form structures of an ectodermal nature, in spite of the fact that we know their environment must be trying to make them develop along mesodermal lines.

Self-differentiation, then, is merely the expression of the determination which was laid upon the cells at an earlier stage. As I have said above, it is probable that all differentiation in the vertebrate embryo is in the last resort dependent

upon the organizer of the first grade. This really means that all *determination* is so dependent. *The expression of this determination may proceed quite independently* of all other structures in the embryo.

Since the organizer of the first grade is located in close relation to the grey crescent (Brachet, 1923), and since the location of this is determined by the point of entrance of the spermatozoon, we must regard the latter as fixing the position of the organizer, as well as of the plane of symmetry.

Hoadley (1926 *a*, *b*, *c*) has brought forward evidence suggesting that determination in the organs of the chick proceeds by a series of steps, the extent of differentiation occurring in grafts of fragments of blastoderms on the chorio-allantoic membrane depending upon the extent to which the region concerned had received its determination at the time of grafting, since further segregation of potencies, or determination, is apparently prevented by the grafting. If this is correct, the process of determination in the regions he used must be dependent upon some organ outside the part grafted, in other words upon some organizer.

Previous Work on Self-Differentiation in the Chick.

I do not propose to give here a complete résumé of the experimental researches which have been carried out on the embryo bird. The purpose of this section is to indicate how great is the self-differentiating power of organs in this embryo.

Perhaps the most important work in this field has been done by Hoadley. This author, using the same technical method as I have used for this paper, has found that the "anlagen" of a large number of organs are able to continue their differentiation in a manner surprisingly close to the normal when living as grafts on the chorio-allantoic membrane. The primordia of the eye, nasal region, otic region, and mesencephalon, when taken from embryos up to the forty-eight-hour stage, and allowed to develop as grafts for about a week continued their development, and histological examination showed that differentiation proceeded as usual (Hoadley, 1924). It was evident that the development of the graft was to a large extent dependent on mechanical factors, and abnormalities were apparently due to similar factors. Physiological isolation itself had little effect. As Hoadley points out, these results (and others yet to be quoted) emphasize the mosaic character of the chick embryo; in other words, the tissues which were to give rise to these structures had received their determination at some time before the grafts were made. *Inter alia*, it is interesting to note that the epithelium of the membranous labyrinth of the ear and the cristae acusticae are able to develop thus without innervation. In a second paper, Hoadley was able to show the ability of the somitic region of the chick to develop and differentiate independently of any innervation, or other influence, from the axial regions, or from regions anterior or posterior to the level at which the graft was made. In general, he used as grafts the region of the chick containing the last five somites before the segmental plate. The embryos from which the grafts were taken were of thirty-six and forty-eight hours' incubation.

In the grafts were found epidermis, cartilage, muscle fibres, nephrogenous tissue, feather germs, etc. Only in the case of the pronephros was the differentiation different from that which occurs normally. In this case, the unusual feature was in the presence of the pronephros, which should have disappeared long before the stage represented by the grafts when removed from the host. Hoadley points out that, while his experiments indicate that a nerve supply is not necessary for the development of these various structures, his results throw no light on

whether or not it is necessary for the maintenance of differentiation (Hoadley, 1925*a*). The same author's third paper on this subject (Hoadley, 1925*b*) does not directly affect subjects with which we are immediately concerned, dealing, as it does, chiefly with the factors involved in the outgrowth of nerves to their peripheral attachments, but it is interesting to notice that the marked specificity which is shown by the different regions of the chick, as shown by the other work of Hoadley and that of others, does not seem to extend to the relations between the nerve cell or fibre and the organ in which the latter terminates. In Hoadley's grafts, in which pieces of mesencephalon were grafted along with somitic tissues, the latter were innervated by nervous processes from the former. It is thus clear that both the mesencephalon and the somitic tissue differentiated specifically, but that the nerve fibres sent out by the cells of the mesencephalon answered, apparently, a direct stimulus of some kind sent out from the somitic tissues. Now, the mesencephalon is that part of the brain which includes the correlation centres for sight, and its cells can never normally innervate muscles, etc. Hoadley, therefore concludes, it seems to me quite justly, that in spite of the specificity of the cells themselves, the forces of attraction involved in the development of nervous connections must be unspecific.

More recently, Hoadley (1926*a*, *b*, *c*) has investigated the development of the eye, feathers and skin, and pro- and meso-nephros. He brings forward evidence in favour of his view that determination proceeds by progressive dichotomy of the "pre-primordial segregates", that this progressive dichotomy is inhibited after grafting, and therefore that the extent of the differentiation attained by any graft is a measure of the extent to which this process had been completed at the time of grafting.

Passing from the work of Hoadley, one may notice an interesting paper by Atterbury (1922-23) which supports the general thesis of the mosaic character of the chick embryo. Atterbury grafted on to the chorio-allantoic membrane the rudiment of the metanephros. She found that characteristic nephric vesicles were formed, and that, in general, the secretory part of the kidney did not differ from the normal. A ureter formed with collecting buds and the kidney appeared to be physiologically active.

Danchakoff and Agassiz (1924) grafted parts of the blastoderms containing neural tubes or plates on the chorio-allantoic membrane, and found a high degree of independence of regions anterior and posterior to regions grafted.

In a recently published paper (Murray and Huxley, 1925*b*) Huxley, in collaboration with the present writer, described three grafts, of which one had developed from the anterior third of a 24-hour embryo, one from the middle of the body of a 24-hour embryo, and one from the middle of a two-day embryo. All three reached a high degree of differentiation in complete separation from all other regions, anterior or posterior to those grafted. As will be seen later, similar results have been incidentally obtained in the present paper.

Attention was called in the introduction to the brief paper (Murray and Huxley, 1925*a*) in which a grafted femur was described.

Finally we must mention the work of Spurling (1923) who extirpated the posterior limb buds of chicks of about sixty-five hours' incubation, and found that not only was the limb never regenerated, but that removal of a part of the pelvic girdle rudiment resulted in a deficiency in the developed girdle corresponding to the part removed.

SELF-DIFFERENTIATION OF THE LIMBS.

Before proceeding to discuss the grafts themselves, it will be well to consider the early development of the limb, as indicated by the buds of embryos of three, four, and five days' incubation, the three ages from which buds have been used as grafts. The grafts from two-day embryos were, of course, derived from tissues which had not yet developed into buds nor shown any other signs of their future destiny.

The form of the bud of the three-day chick is shown in Figs. 45*b* and 46*b*. It is at this stage a long low swelling of the lateral body wall, the length of the base of the bud being much greater than the length in the axis of the future limb. These two figures show only posterior limb buds, but the condition of the anterior bud is similar. In section the buds are seen to consist of a fairly dense mass of mesenchyme. There is absolutely no sign whatever of the axial condensation which appears in later stages, and which is the first visible indication of the limb skeleton.

A number of figures show the limbs of four-day chicks, and examination of them reveals to us how great is the variability in the degree of development attained at this stage. It should here be stated, however, that this variation indicated here must surely be greater than the "true" variability of the limb, as the term "four-day" (like two-, three-, and five-day), is only approximately accurate, and in reality varies about six hours in each direction, while the incubators used frequently showed considerable variations in temperature. For this reason I have shown in nearly all cases, along with the figure of the graft itself, a figure of the limb bud which was the fellow on the opposite side of that which was used for the graft. Thus the grafts can be considered in relation to the buds from which they come, rather than in relation to their approximate ages. The earliest stages at which I have found buds of four-day chicks are shown in Figs. 2*b*, 30*b*, 1*b*, 8*b*. In that shown in Fig. 2*b*, perhaps the least developed of all, the bud is little, if at all, advanced beyond the conditions shown in the figure of the buds of three-day chicks (Figs. 45*b* and 46*b*). Sections of such a bud as this show no essential difference from the picture seen in sections of the buds of the three-day embryo, and the same applies to sections of the bud shown in Fig. 1*b*, except that, in this bud, the whole structure being a little larger, there is more mesenchyme, and the latter is perhaps denser than that shown in Fig. 2*b*. Nevertheless, there is still no sign of any axial condensation. Of this group of limb buds, all are posterior buds, except that shown in Fig. 30*b*. More advanced stages of buds at the same approximate age are shown in Figs. 13*b*, 11*c*, 12*b*, 18*b*, for posterior buds, and in Figs. 9*b*, 23*b* for anterior buds. In such buds as these, the length of the axis of the limb is as great as, or a little greater than, the length of the base of the bud. In sections such buds as these show a dense mass of mesenchyme throughout, but still little or no sign of a special axial condensation. The more advanced of them, such as Fig. 18*b*, may show some slight commencement of it in the basal regions of the bud. Somewhat more advanced buds, still of approximately four-day chicks, appear in Fig. 5*b* for the posterior bud and in Fig. 36*c* for the anterior bud. In these the bud is verging on the form seen in buds of five-day chicks. Such buds show in sections a distinct axial condensation of the mesenchyme, indicating the general position, but hardly yet the outline, of the future skeleton.

Passing to the buds of five-day chicks, we see in Figs. 42*b*, 41*b*, and 37*b*, examples of the less advanced of the posterior buds of five-day chicks, and in Fig. 35*c* the same for the anterior bud. It will be seen that the main advance

which these buds have made over the buds of the more advanced four-day chicks lies in an expansion of the distal end of the bud, indicating the beginning of the foot plate, which we see better developed in such more advanced buds as those shown in Figs. *31d* and *38f* for the posterior bud, and in Fig. *44c* for the anterior bud. In these more advanced posterior buds the foot plate is a marked expansion, and the rudiments of the digits, now in the process of formation, can be detected externally as slight ridges. Naturally, these are not so clear in the anterior bud. Sections of the more advanced buds of this age show the skeleton clearly laid down in general outline as a dense mesenchymal condensation, even very early cartilage, showing clearly the femoral region, the tibia and fibula, the foot region represented by an expansion of the fused anterior ends of the tibular and fibular rudiments, while I have been able to detect at least three toes. The same applies to the anterior bud, in which, also the skeleton is at this stage clearly laid down.

THE EXTENT OF THE SELF-DIFFERENTIATION IN BUDS OF THREE, FOUR, AND FIVE DAYS.

We have to consider whether a graft upon the chorio-allantoic membrane can truly be said to develop independently of the body of the host chick. There is no doubt that this can be stated with every confidence, provided certain reservations are made. In the first place, the graft receives its blood supply from the host, and all that the blood contains, that is, principally food and hormones. That hormones play some part, and a highly important part, in growth and differentiation, is, of course, well known, and that the limbs would fail to develop in the absence of a hormone supply is very probable. Thus, so far as hormones are concerned, this method does not show self-differentiation. At the same time it must be pointed out that the grafted buds are receiving the hormone supply of an older chick than that to which they properly belong, and it is at least very probable that the hormone system of the 8-day chick is very different from that of the 4-day. This is a criticism which applies to all the methods used to demonstrate self-differentiation in vertebrates except, perhaps, that of tissue-culture; though even here it would generally be difficult to be certain that hormones were rigidly excluded from the medium. The influence of hormones is chiefly exerted upon growth, and upon special chemical processes like deposition of calcium, etc., and no one, I think, would suggest a hormone action causing, by a direct stimulus, the formation of a limb from a limb bud, the laying down of cartilage in special areas, or the segmentation of the continuous "sclero-blastema" into the individual elements of the limb. Very possibly the processes of chondrification and ossification would fail to occur in the absence of hormones, but the particular areas of deposition of cartilage and bone, areas of rapid growth, and areas of slow growth, etc., must be represented by some kind of pattern in the developing limb itself. In the second place there are two slight possibilities which we must remember, however remote they may be. No nerves are known to exist in the chorio-allantoic membrane, and, in an animal so widely studied as the embryonic chick, it is perhaps hard to believe that they could have been missed had any extensive nervous apparatus been present. Nevertheless, the difficulty of proving a negative, forces us to recognize, as a remote possibility, that nerves may be present. Whether there are nerves present in the chorio-allantoic membrane or not, it is unquestionable that this membrane is itself continuous with the body of the host chick, and hence that the graft is likewise in continuity with the host. Now it has been amply shown by workers in Amphibians (Harrison, Gräper, etc.) that the body of the animal exerts an influence upon the limb, and it seems certain that this influence is neither nervous nor humoral.

It must, therefore, travel from cell to cell. Can it be that the limb buds of the chick, grafted upon the chorio-allantoic membrane, are able to develop there, because they receive some similar impulse travelling from cell to cell, all the way from the host to the graft? The possibility is there, but the arguments against it show its improbability so strongly, that we can have no hesitation in rejecting the idea. Consider, first, the mere distance. In normal development such impulses affecting the development of the limbs travel only for a very short distance within the body of the embryo. In the case of the graft on the chorio-allantois, these impulses would have to travel a vastly greater distance, and there is no special conducting mechanism (like nerves) for them to travel along. It is at any rate extremely probable that impulses of this kind travelling along unspecialized protoplasmic pathways suffer a decrement the further they get from their source. This is, at any rate, the case in Protozòa (Verworn, 1913, chapter 6). If the impulses we are discussing suffer such a decrement, it is surely extremely probable that, long before they reached the graft, they would be entirely wiped out. Further, such impulses of this kind as have been shown to affect limbs, are mostly concerned with the determination of symmetry, etc. Examination of the figures shows clearly that the symmetry was determined at the time of grafting. It can hardly be argued that the grafts show their symmetry because they receive symmetry-determining influences through the membrane, since it is obvious that the influences from both sides would travel equally along the membrane and hence would cancel.

We may then conclude that the isolation of the graft limb buds from the host chick is complete, except as regards hormones and except of course, food, isotonic medium, etc.

It remains for us to examine the behaviour of the buds developing under these conditions.

Grafts of Entire Limb Buds.

Only a few grafts of entire limb buds were made, since, if fragments of buds are able to self-differentiate, it is reasonable to deduce that entire buds would have the same faculty.

Five grafts derived from entire limb buds of four-day chicks have been dealt with in the descriptive part of the paper. The most interesting of these is No. 1 (Figs. 1*a*, 1*b*) which, as an inspection of the figure will readily show, is a practically complete limb. It will be noticed that this very perfect specimen developed from a bud which was at a comparatively early stage considering the age of the embryo from which it came. Sections of the bud showed no trace of axial, pre-skeletal condensation. The remaining grafts obtained from entire buds all showed varying degrees of abnormality. The significance of their abnormalities will be discussed later. We can conclude, then, that the posterior limb bud, at the stage indicated by Fig. 1*b*, can develop by self-differentiation.

Grafts of Fragments of Buds.

We can learn from the study of grafts of fragments of buds, the extent to which the limb bud is itself divided into a mosaic of regions, each destined to give rise to a particular part of the limb and to no other, and the extent to which regulation can occur in these fragments. We shall find that, just as the work of Hoadley and others has shown the chick as a whole to consist of a mosaic of regions, each of which has already received its determinations, so that, when grafted, it can develop into that part which it would normally form and no other,

so the limb bud at four days is similarly divided, while the little evidence indicates very strongly that the same is true for the bud at three days. We shall also see that the view put forward in a previous paper (Murray and Huxley, 1925*a*) that a considerable amount of regulation can occur in the grafted fragments of limbs requires modification.

In a certain number of cases, where two halves, or three thirds, or four quarters of a bud have been grafted separately into different hosts, the two halves, or two or more of the thirds or quarters have "taken" from the same bud. These "sets" are of particular interest, because they show most clearly the mosaic constitution of the bud, and the slight amount of regulation of which its parts are capable. Since it is not usual for more than about 20% of attempted grafts to be successful (in one case 70%, but frequently none), only a small number of "sets" have been obtained, compared to the total number of grafts. Sets are shown in the following figures: *a*, from the three-day chick (Fig. 45); *b*, from the four-day chick (Figs. 6, 7, 8, 9, 10, 29—the only set from a bud cut longitudinally); *c*, from the five-day chicks (Figs. 31, 32, 33, 35, 36). In the descriptive part of the paper these have been described as individual grafts, not in relation to one another as parts of sets. This will be our next step.

The "Sets".

(*a*). From the three-day chick: Nos. 57 and 58 (Figs. 45*a*, *b*, and *c*).—No. 58 (Fig. 45*c*) is the only one of these two grafts whose differentiation has been in any way satisfactory, so as to form a structure containing elements which can be recognized with a fair degree of certainty. As we have already seen, it consists of the distal part only of a femur, of a tibia and fibula, and of a single toe. It is important to note that the femur is incomplete proximally. No. 57 has developed but poorly. If it can be taken as representing an attempt at a femur, one would, from its general shape, be inclined to regard the thick end as the proximal, and the thin as the distal end. If this be correct, the two grafts together constitute a femur in two parts, a tibio-fibula, and an attempt at a foot.

(*b*). From the four-day chick: Nos. 6 and 7 (Figs. 6*a*, *b*, *c*, and *d*).—Of these two grafts one has formed an excellent femur, the other a tibio-fibula and foot, the tibia and fibula being incomplete proximally. The two together thus do not constitute a complete leg. Nevertheless, the proximal region of the bud formed a femur without anything more distal, while the distal region formed nothing proximal to the tibio-fibula. The incomplete proximal end of the tibio-fibula is probably due to the cut edge of the distal half of the bud having been damaged by the knife.

Nos. 8 and 9 (Figs. 7*a*, *b*, and *c*).—We have seen reason for regarding No. 8 as an abnormal femur and tibio fibula, and No. 9 as an imperfect foot, probably with the distal end of at least a tibia. The doubt which surrounds these two specimens, however, greatly decreases their value as a "set".

Nos. 10 and 11 (Figs. 8*a*, *b*, and *c*).—These two specimens, from their very poor differentiation, do not interest us at the moment.

Nos. 12 and 13 (Figs. 9*a*, *b*, and *c*).—We have already decided that the cartilage marked (*Hum.*) in No. 12 (Fig. 9*a*) is probably the humerus, which, from its pointed distal end, is evidently incomplete. In No. 13 (Fig. 9*c*) we find a well-developed wing with the distal end, only, of a humerus present. If, then, this interpretation of No. 12 is correct, these two grafts together constitute a whole wing. It is important that the humerus is in two parts and that both parts are incomplete.

Nos. 14 and 15 (Figs. 10*a* and *b*).—This "set" is important as possibly providing one of the few examples where the *same end* of an element is present in two grafts. No. 14, as we know, consists of the distal end of the femur and of the proximal ends of the tibia and fibula, while we have seen reason to suppose that something not far removed, at any rate, from a complete tibia and fibula is present in No. 15. Could we be confident that this interpretation of No. 15 was accurate, this set would be of paramount interest, as it would be a clear case of regulation, but unfortunately we cannot be sure that the tibio-fibula of No. 15 is not incomplete proximally. The incomplete proximal end of No. 14, of course, means that the femur has failed to undergo regulation so as to form a complete element.

Nos. 34 and 35 (Figs. 29*a*, *b*, and *c*).—This "set" is of particular interest for a number of reasons, largely dependent on the fact that it is the only set I have from two longitudinal halves of a bud. Considering first the femoral regions of the two grafts, we find that each has a femur, but that in neither is the femur complete. That of No. 35 (Fig. 29*b*) is to all appearances complete at its proximal end, where it has a head and a trochanter, while at the distal end the place of condyles is taken by a rounded ending to the element not unlike a single condyle. No. 34, on the other hand, lacks both head and trochanter, while its distal end is not unlike that of No. 35. The lack of head and trochanter is not, as might be supposed, due to lack of the proximal end of the femur, itself due to the original cut having been oblique to the femur-determined region, since part of the pelvis is present in close relation to the proximal end of the femur in the graft, since the region of replacement of cartilage is in the middle of the graft, and not towards the proximal end (compare Fig. 10*a*, where the femur is really incomplete at the proximal end and the cartilage has been replaced at this end of the graft), and since the region of maximum ossification is situated around the central region of the femur (compare again Fig. 10*a*). We must conclude then that this graft included a longitudinal fragment of the proximal end of the graft, but failed to develop here either trochanter or ilium, while its fellow fragment, No. 35 (Fig. 29*b*), did develop both head and trochanter. The obvious conclusion is that *the latter graft included that part of the femur-determined region which contained the tissues destined to form both head and trochanter*, while its fellow graft did not contain them and was unable to undergo regulation sufficiently to form them. At the condylar end of the two femora, addition of the two rounded ends to one another would give a pair of condyles, suggesting that the original cut went through the middle of the region of the bud destined to form condyles, and hence the two grafts formed each one condyle, being unable to form a pair. That this is the correct explanation is further indicated by the fact that one graft contains what is apparently a tibia and the other a fibula. So far our examination of these two femora has shown us a remarkable inability of longitudinal halves of an element to form any more than they would have formed in normal development. But when we come to examine the body of the femur in each case, we find here an interesting and obvious case of regulation of form. Since each graft originated from approximately half the femur-determined region of the bud we should, if no regulation can occur at all, expect to find that each graft consists, not of a rounded, solid-cylindrical femur like that of a normal embryo, but of a structure which, in cross-section, would have the form of a half-circle, and, after replacement of the cartilage in the middle of the femur, of half a hollow cylinder in this region. In other words, we should expect each graft to be like half of a femur split down the middle. In actual fact, this is not what we find. Each

graft contains a femur which in cross-section would be approximately circular, with the cartilage in the middle and a veil of bone round the outside of the section, while in the middle region of each femur we should see in section that the cartilage has been replaced. Obviously then, regulation of form has occurred here to this extent, that a longitudinal half of the femur rudiment has formed, in each case, a rounded shaft. This is the only definite case of regulation which we shall come upon in our study of the grafts.

Leaving now the femoral region of these two grafts, we find in the remainder of the limb that No. 34 (Fig. 29*a*) has a tibia and a small fragment which is probably a fraction of the fibula, and two toes, while No. 35 (Fig. 29*b*) has a fibula and again two toes. Thus in the remainder of the limb we find no sign of regulation, but a very beautiful proof of the mosaic structure of the limb bud at four days.

(*c*). From the five-day chick: Nos. 37, 38, 39 (Figs. 31*a*, *b*, *c*, and *d*).—This is a most interesting set, but is unfortunately incomplete. The posterior bud of the donor chick was cut transversely into four pieces, of which successful grafts were obtained from the basal quarter (No. 37, Fig. 31*a*), the next quarter distal to the basal (No. 38, Fig. 31*b*), while the next distal quarter failed to take. The most distal quarter of the four took (No. 39, Fig. 31*c*). A glance at the figures shows us the mosaic character of the buds at five days very beautifully, the three grafts having formed the one a femur, the next a tibia and fibula, and the last a foot. That the femur (Fig. 31*a*) is a complete structure is obvious at a glance and such a conclusion seems also to be justifiable for the tibia and fibula formed by the next quarter (Fig. 31*b*). It is true that the tibia lacks the joint structures normally found at its extremities, but we have seen, in the descriptive part of the paper, other reasons indicating that this element is almost, if not quite, complete.

Nos. 40 and 41 (Figs. 32*a* and *b*).—Of these two grafts, one is a femur with part of tibia and fibula, and the other, part of the tibia and fibula and a foot. The interesting point is the division of the tibia and fibula into two parts, both incomplete. This clearly indicates that, even though a graft contains part of an element like the tibia, it will not be able to form the entire element, so this case and others like it force us to recognize that the limb is a mosaic, and that the size of the pieces of this mosaic is less than that of a single element like the tibia. We shall see further evidence bearing on this point, and we shall also see cause for slightly modifying this statement.

Nos. 42 and 43 (Figs. 33*a* and *b*).—This set is essentially similar to the last, each part containing part only of the tibia and fibula. It is interesting to see that in No. 42, Fig. 33*a*, whatever the cause, the femur has been divided into halves and each half has remained incomplete.

Nos. 45 and 46 (Figs. 35*a* and *b*).—It will be remembered that in the descriptive part we were unable to decide definitely whether or not No. 46 contains the radius and ulna. If not, then these elements are absent from both grafts of the set, a state of affairs for which the most obvious explanation would seem to be destruction of their rudiments during grafting, by the knife or in some other way. However this may be, this specimen gives no indication of regulation but, like the others, indicates mosaic development.

Nos. 47 and 48 (Figs. 36*a*, *b*, and *c*).—This set is incomplete, the distal third into which the bud was divided having failed to develop. The two parts existing are a humerus and a radius and ulna.

We see, then, from a study of the "sets", that the limb bud of the four-day, five-day, and almost certainly of the three-day chick is already marked out into

a mosaic of regions, each region being destined to form a particular part of the future limb and having but very slight powers of regulation.

The weakest link in the chain of evidence here is in the three-day chick, of the limb buds of which I have only three grafts (Nos. 57 and 58 (Fig. 45) constituting a set, and No. 59 (Fig. 46), an isolated graft, i.e., not a member of a set). It is hoped that in the future it may be possible for me to investigate the potentialities of the buds of three-day chicks more thoroughly. Nevertheless, in spite of the slight amount of material available, it provides evidence of sufficiently definite character to enable us to draw conclusions with a high degree of confidence. We have already examined this evidence as it comes to us from Nos. 57 and 58; we must now turn to No. 59 (Fig. 46). This, as we have already seen in the descriptive part of the paper, is a nearly complete limb, but shows signs of incompleteness in the proximal part of the femur. The intention in the experiment was to divide the bud transversely. Now, the bud of a three-day chick is a very small structure and it is very easy to mistake its orientation after removal from the chick, or to direct one's knife wrongly in making the cut. The graft certainly seems to be incomplete and the natural thing to believe is that this is actually the case, the proximal end of the femur being obliquely incomplete as a result of mistaken direction in making the cut. In this case, No. 59, like other grafts, including the others from three-day chicks, gives us evidence of the mosaic structure of the limb bud, even in the three-day chick.

Isolated Grafts.

In addition to the sets, there are a number of grafts which have been described and figured for various reasons. That these afford additional evidence for the mosaic conception of the structure of the limb bud we shall see, but it will not be necessary for us to discuss them seriatim. They have all been adequately described and figured in the descriptive part of the paper.

The outstanding points to be learnt from them are the following: (1) Grafts from basal fragments of limb buds always, if they develop successfully, give rise to basal structures and no others, and, likewise, grafts of apical fragments give rise to apical structures and no others. Apparent exceptions to this rule will be discussed. (2) If the rudiment of an element like the femur or the tibia be divided in cutting up the limb bud, the graft resulting from one of the pieces may develop that part of the element of which it contained the rudiment at grafting, but no more. This is true subject to a reservation shortly to be made. (3) The evidence indicates that not only the limb, but also the pelvic and pectoral girdles are mosaics. That this is the case for the pelvic girdle at least has already been shown by Spurling (1923).

The first point will be sufficiently illustrated by references to the following figures: From the three-day chick, Figs. 45 and 46; from the four-day chick, basal fragments of posterior buds, Figs. 6*a*, 7*a*, 10*a*, 11*a*, 12*a*, 13*a*, while 17*a* which is apparently the distal end of a femur and a tibio-fibula, both but poorly developed, came from the middle third of a bud; from apical fragments of posterior buds, Figs. 6*d*, 7*c*, 10*b*, 18*a*, 19*a*, 20; from basal fragments of anterior buds, Figs. 9*a*, 22; from apical fragments of anterior buds, Figs. 9*c*, 23*a*, 24*a*, 25*a*, 27*a*, 28; from longitudinal halves, Fig. 29*a*, *b*, and *c*; from the five-day chick, basal fragments of posterior buds, Figs. 31*a*, 32*a*, 33*a*, 34*a*, 37*a*, 40*a*; from middle fragment of a posterior bud, Figs. 31*b*, 43*a*; from apical fragments of posterior buds, Figs. 31*c*, 32*b*, 33*b*, 41*a*, 42*a*; from basal fragment of anterior buds, Figs. 35*a*, 36*a*, 44*a*, 44*b*; from middle fragment of an anterior bud, Fig. 36*b*; from apical

fragment of an anterior bud, Fig. 35*b*. This list refers not only to isolated buds, but also to a number which are members of sets.

The second point is illustrated in a number of the figures referred to in the last paragraph, in which incomplete elements are shown, indicating the inability of the part of the rudiment of that element contained in the graft to form more than it would have done under normal conditions. Thus it has been found necessary to reverse the opinion formed in a previous paper (Murray and Huxley, 1925*a*) where it was concluded that "A fragment of the femur-rudiment of the four-day chick can undergo regulation and form a complete femur". Although this statement is now shown not to have been correct, there remains reason for believing that a certain amount of regulation must occur in some, at least, of these grafts. In early stages of the development of the limb, when the skeleton is recognizable as a sclero-blastema, the different elements of the skeleton and the limb girdle are all in continuity with one another (Johnson, 1883). Now, there are a number of grafts in which, at the end where the cut was made (i.e., both ends of a basal piece and the proximal end of a distal piece) the element there present ends, not incompletely, but in a well-formed terminal structure like the head in Fig. 12*a*, or the condyles in Figs. 31*a*, 6*a*, or 36*a*, or like the head of the femur, the reconstruction of which is shown in the previous paper (Murray and Huxley, 1925*a*).

The Mosaic.

Now, we have shown, conclusively enough I think, that the limb bud is a mosaic, but we have not decided whether any two different regions of this mosaic in contact with one another should be regarded as separated by an absolutely sharp dividing line so that a cell on one side of the line would belong, for instance, to the femur and one on the other side to the tibia, or whether the two regions should be regarded as shading off into one another so that between the two would be a narrow but ill-defined "No man's land". I believe the weight of the evidence and of general probability favours the second alternative. To take the former view would mean that in these cases where the graft at what was the cut end, ends flush with the ending of a skeletal element, the original cut must have passed *exactly* along the line separating the anlage of the element contained in the graft from the next contiguous one, not contained in the graft. Such a thing might happen occasionally, but must be very rare, for the size of the bud is not great, that of the rudiment of the skeleton is smaller, and, since nothing was known as to the location of special regions of the skeleton rudiment, no effort was made to place the knife between the anlagen of any two skeletal elements. Thus it is extremely probable that, in these cases where the graft ends flush with the ending of a complete skeletal element, the knife really went only approximately between the anlage of this element and that of the contiguous one. In some cases the graft would contain a little less than the whole of the anlage ending at this point, at other times it would contain the entire rudiment plus a little more of the next contiguous. Very rarely would the cut pass exactly along the dividing line. In cases where the cut passed through the end of the next contiguous element one would expect that the graft would contain a small fragment of cartilage belonging to this element, while, if it passed through the end of the one contained in the graft one would expect some incompleteness at this end of the element. In neither case would one expect what is actually found, a complete end to an element with no trace of the next one. Further, it is hard to believe that the knife does not kill a number of cells and so damage others and

disturb their arrangement as to make it impossible for them to take part in the differentiation of the skeleton. If this is the case, as surely it must be, one would not expect to find instances like the two shown in Fig. 31*a* and *b*, where the basal quarter of a bud has formed a complete femur and the next apparently a complete tibia, since the cells responsible for forming the contiguous ends should have been destroyed by the knife.

Now, if one takes the alternative view, that the boundaries between two adjacent regions of the mosaic are marked, not by hard and fast lines, but by zones where the influence of each region shades off into that of the other, these difficulties disappear. The cut, in order to separate two elements from one another, needs not to follow exactly a sharp line of division, but only to fall within a comparatively wide belt of tissue lying along the boundaries of adjacent anlagen.

This idea reminds us at once of the "Wirkungskreis" theory of Weiss (1925). This term I propose to translate by "Reaction System", which has the advantage of bringing the idea into relation with a number of similar ideas current in experimental embryology and related subjects, while it is naturally particularized by association with the name of Weiss. Each single "Wirkungskreis" or reaction system, of the lowest grade, is thought of as an equipotential system. Thus an egg which is an equipotential system is a single Reaction System or rather is a single "determination field" (Weiss, 1925). As development proceeds, and the embryo ceases to be an equipotential system, the single determination field becomes divided, while each smaller equipotential system is a reaction system until it too is subdivided. Thus, we have a determination field for the entire embryo, smaller fields for organs, for particular parts of organs, and for tissues. Applying this idea to what we know of the constitution of the limb bud of the chick, we should regard each region of the mosaic, which is by definition an equipotential system so long as it is not as small as a single cell, as a single "reaction system", which received its determination from some influence in a determination field in an earlier, and as yet uninvestigated period in its development. The limb bud would thus be divided into a femur system, a tibia system, etc. Each of these reaction systems must be thought of as restricted to a certain area and as exerting some kind of control within that area. Thus, if a graft contained the femur area and, in addition, a large part of the "No man's land" between the femoral and the tibio-fibular areas, the tissue originally in the boundary zone would come under the control of the femoral region and be thereby converted into femoral tissue. It should be pointed out here that the femoral and tibio-fibular regions are used purely as examples; as we shall see shortly, the actual size of the smallest pieces of the mosaic must be much smaller than these areas. The actual evidence in favour of this view of the constitution of the chick limb bud is of course not complete, and the idea is advanced in a tentative manner. Nevertheless, it is quite certain that the limb bud is a mosaic of regions determined in various directions (femur, foot, etc), and it is probable that there do exist, between adjacent regions of the mosaic, boundary zones of tissue which can be converted into part of either of the two elements between which they lie, according to which of these regions gains control of them.

The Size of Mosaic Regions.

The experiments described in the present paper do not completely answer the question, "What is the size of the pieces of the mosaic"? Nevertheless, it is possible by an examination of the material to obtain certain data. It is at once clear that an element like the femur or the tibia contains more than one piece.

Otherwise a fragment of the region, when included in the graft, should form an entire femur, humerus, etc., as the case may be, and we have already seen in a number of specimens that this is not the case. Examine Figs. 9*a*, 9*c*, 10*a*, 12*a*, 13*a*, 17*a*, 20, 32*a*, 32*b*, 33*a*, 33*b*, 34*a*, 43*a*, 45*c*. In our study of Nos. 34 and 35 (Figs. 29*a*, *b*, *c*) we found reason to believe that the femoral region was divided longitudinally into a mosaic, so far at least, as its extremities are concerned, while in the same specimens we found that there is a dividing line down the middle of the bud, so that the tibial region is separated from the fibular, and two toes on one side from two on the other. In most cases the grafted fragments have not been small enough for us to go further than this, but in No. 33 (Fig. 28) we have a specimen which tells us that in the anterior bud of the four-day chick the region distal to the line between the metacarpals of the second and third digits is separated off as part of the mosaic from the proximal regions.

Exceptional Specimens.

I have in my collection of grafts two specimens which, at first sight, seem not to be in accord with the others, nor with the arguments put forward above.

No. 50 (Figs. 38*a*-*f*), supposed to have originated from a basal quarter of a posterior bud of a five-day chick, has formed a graft consisting of a femur, tibia, fibula, and two rods of cartilage in the position of a foot, and evidently representing an attempt to form some kind of foot structure, or part of one. Unfortunately the fellow grafts from the other parts of the same bud all failed to take; were they available we should be able to say for certain whether or not we are here dealing with a case of regulation. Examination of the entire, cleared specimen showed at once from differences in staining the fact that the histological differentiation of the femur and tibio-fibula of this graft is much more advanced than is that of the "foot", and this is shown to be correct by the study of sections. Now, there are two alternative explanations of this specimen. One is that we have here a case of regulation, a fragment of a limb bud having given origin to nearly a whole one. This brings us into conflict with all the remaining material (except the next specimen to be considered), which, as we have seen, shows only the slightest ability to regulate. The alternative is that a mistake was made in the grafting, the limb bud being divided into four very unequal parts, the basal part being very large, equal to half or more of the bud, and the cut being made obliquely so that a part of the foot anlage was included. The division of the buds into parts was always done approximately, so that a "half" or a "quarter" of a bud merely means that the bud concerned has been divided into two or four parts, not necessarily equal. It is much more probable that this is what happened in making this graft, than that we have here a specimen which runs counter to all the others. The less advanced differentiation of the foot region might be taken as indicating regulation here, but it seems just as probable that this region suffered some damage in grafting and that its development has been in consequence delayed.

No. 31 (Fig. 26).—This bud is supposed to have originated from an apical half of a fore bud, and yet it appears to be a complete wing. Another graft was undeniably made from the same bud, and hence this cannot have been an entire bud grafted by mistake. The bud was grafted in two pieces, an apical piece, which gave rise to this graft, and a basal piece which did not take. I am inclined to the view that the correct explanation here is that the apical piece was very large, including nearly the entire bud, while the basal piece was a tiny fragment which, had it taken, would have developed into part of the pectoral

girdle. This view I take because the alternative one, that a fragment has undergone regulation and formed a complete wing, would be contrary to the evidence obtained from all the other grafts.

THE FACTORS CONCERNED IN THE DEVELOPMENT OF BONE FORM.

The form of parts of the skeleton and the influences at work in producing them have been studied by many workers. The general attitude appears to be to regard the form of bones and joints as developed at birth as inherited, but as largely affected, after birth, by the physical conditions of posture, gait, etc. Weidenreich (1922), for example, has made a study of the parts of the skeleton of the foot of normal men, various kinds of cripples, and of primates, paying particular attention to the heel. From a study of the foot, and especially of the calcaneus, of men and apes he concluded that the form and internal structure of the calcaneus are characteristic for each form and are determined by mechanical conditions dependent on stance and gait. In cripples, whose foot had never touched the ground, the heel was very abnormal and all those features which are traceable to mechanical factors were absent, and similarly in cases of club foot, the abnormalities correspond to the abnormal mechanical conditions. He points out the resemblance between the fœtal human foot and that of an ape, the human characteristics developing later in answer to functional needs. This was shown especially by the foot that had never touched the ground, and which, in adult life, still retained the fœtal form. From this Weidenreich concludes that the normal form of the heel is not inherited but is acquired as a functional answer to mechanical conditions. His general conclusion is that the form of adult bone is not inherited, but that the ability to develop this form as a reaction to the conditions is inherited. He also points out the action which muscle plays in the development of the form of bones. In his case of Pes equinus, the degeneracy of certain extensor muscles is correlated with the absence of the anterior angle of the tibia, wherein this tibia resembles those of the fœtus and of young children. Weidenreich then, apparently believes that a certain bone form is inherited, and that this is the bone form at birth, but that after birth a certain amount of change of form occurs as the result of the action of the mechanical conditions of stance and gait. Probably there are few who would disagree with him.

Koch (1917) made a very detailed and thorough study of the structure of the normal human femur from a mechanical point of view. His general conclusion is that "the inner structure and outer form of the femur are governed by the conditions of maximum stress to which the bone is subjected normally by the preponderant load on the femur head". So far as the outer form of the femur is concerned, its general shape is laid down in the embryonic cartilaginous skeleton, the form of which cannot be determined by "the preponderant load on the femur head", since when the cartilaginous skeleton is laid down the limb is, of course, non-functional, and also since the grafts to be mentioned shortly have attained a practically normal form in the absence of any load on the femur head. Koch's study shows, indeed, that the femur is beautifully built to fulfil its functions, but he is not necessarily justified in concluding that it is the stresses and strains met with in exercise of that function that determine the external form of the bone. So far as the bony architecture within this form is concerned, one cannot but feel strongly, with Koch, that this is determined by the mechanical conditions of function, at least so far as the adult bone is concerned. Doubtless, also, the maintenance of the form originally given to the fœtal bone by the cartilaginous skeleton is dependent upon normal conditions of stance and gait.

Gräper (1922) stated it as his opinion that the form of joints was decided by functional adaptation, but admits that a definite joint form is inherited and develops at first independently of function. He cites an interesting case in his grafts where bones ended immediately beneath the skin, the next element being absent. These were bone ends which, normally, form a pulley joint. Under these experimental conditions, however, they formed, not a pulley, but a rounded ending (Kugelform). This reminds one of the sheep described by Jenny (1912) which lacked one foreleg, and the scapula, instead of having a hollow joint cavity, had a rounded head. Gräper found cases among his grafts in which three and more elements met in one joint, and found that the joint always adapted itself to these conditions.

Braus (1910), by means of a technical method which need not be described here, was able to cause to develop a small shoulder girdle in relation to a larger limb. The acetabulum was thus small and the head of the femur large, and consequently the two did not fit well. In spite of this, the form of each was fairly normal, so apparently in this case the normal form of the joint structures did not depend on the presence of the other normal joint.

Carey (1921, 1922*a*, 1922*b*) has elaborated a new conception of the factors concerned in bone and joint formation. He regards the developing bud as being in a condition of accelerated growth in the central skeletal region, and of retarded growth in the more peripheral region, while each skeletal element he believes to be represented by a distinct zone of accelerated growth. Thus, as development proceeds, two contiguous growth centres (like the femur and tibia) push up against one another. He states the "Law of joint formation" thus: "The contour of the opposed surfaces forming a joint is dependent upon the intensity of the force of interstitial growth per square millimetre of cross-section of the segments forming the joint, and upon the resistances to the growth of each skeletal element" (1922*b*). The resistances to the growth of the skeletal elements he regards as: "(1) Opposed growth of contiguous skeletal segments. (2) Weight of related soft parts. (3) Reactive elasticity of traction of the soft parts retarded in growth. (4) Active muscular pull" (from abstract on Wistar Bibliographic Service Card for Carey, 1922*b*). In the formation of a joint, which element is to have the hollow joint (like condyles) and which the convex (like the head of the femur) is decided principally by the relative growth rates of the opposed elements, the one which pushes with most energy having the convex joint, the other the concave. We may point out at once that the action of muscular pull as a factor in determining skeletal form *in embryology* is gravely to be doubted, though there can be little doubt that it is a potent factor in modifying the form of bones after birth. (See e.g., Bernhard, 1924, on the influence of muscles on the form of the tibia.) A certain amount of evidence exists, suggesting strongly that the skeleton of a limb can develop without muscles, as in the case of a five-legged frog described by Colton (1922), the supernumerary leg of which was devoid of muscles except over the head of the humerus.

If, now, we test Carey's views by reference to the grafts described above, we shall find that, attractive as these views are, they have not stood the test of experiment. In a number of specimens the normality of the form of the different skeletal elements is most striking. Let us, first, consider how far these experiments can be regarded as tests of Carey's views. If his views on the formation of joints were correct, it would be absolutely necessary for the formation of any one joint surface in anything even remotely resembling the normal manner, that the element bearing the opposite joint surface should be present. Now, as we

have already seen, there are a number of cases in which joint surfaces are developed in a manner which is extraordinarily close to the normal, in the complete absence of the contiguous element, as in the head of the femur shown in Fig. 12*a*, and the head of the femur described in the previous paper (Murray and Huxley, 1925*a*), and the condyles shown in Figs. 6*a*, 31*a* and 36*a*. It cannot be argued that the joint surfaces were already developed when the graft was made, for in the grafts made from five-day chicks the skeleton is still only represented by a continuous blastema, while even this is absent from four-day chicks. It is quite clear that in chick limbs the joints are not modelled by the forces of the opposed growth of the two contiguous elements, which Carey regards as the principal factor concerned. Of the remainder of his list of factors, the "weight of related soft parts" can hardly come into play since the entire graft is enclosed in the membrane, whereas in the normal chick the limb hangs free from the body. The "Reactive elasticity of soft parts retarded in growth" may indeed act in the grafts but the normal relations must be very much disturbed by the general abnormality of the grafted state, and, anyhow, Carey does not seem to attach much importance to this factor so far as joint formation is concerned. The fourth factor, "Active muscular pull", may act to some extent, since muscles are undoubtedly present in the grafts. In cases like Fig. 31*a*, however, where only one element is present in the graft (barring the pelvic parts) the muscles which would normally run to have their insertion on an absent element, e.g., the tibia in Fig. 31*a*, cannot be attached at both ends to bone, unless they are attached twice to the same bone. Either way, whether they are attached twice to the same bone, or whether one end lies free in the mesenchyme of the graft, it is difficult to believe that they could in any way influence the development of the skeleton except in a highly abnormal manner. It seems then, that none of the principal factors adduced by Carey as determining the form of bones and joints can be held to be effective in the grafts. It will be interesting, in the future, to examine the muscles in such grafts with a view to testing the same author's hypotheses relating to muscle differentiation. In the present work I have concentrated almost entirely on skeleton, for the study of which it has usually been necessary to dissect away the muscles. Certainly, one would expect Carey's hypothesis of optimal tensional stresses as determining muscle development from the mesenchymal cells to be correct. As regards the formation of the periblastemal membrane round the axis of the long bones I have nothing to say. It is, so far as I am aware, quite probable that on this point Carey may be correct, and that this elongation of the peripheral cells of the central area of accelerated growth may be the method whereby the width of the element is primarily determined. One more point must be mentioned here. Carey attributes the bend of the axis of the femur to the resistance at the acetabulum and knee, and to muscular pull. The latter we have already discussed, while the former seems invalidated by such grafts as shown in Figs. 12*a* and 31*a*. The former lacks the pelvic girdle completely and therefore the acetabulum, while the latter contains part of the girdle but lacks the knee joint. It may be argued that the boundaries of the swelling in the membrane in which the graft is contained would provide the necessary pressures, and this may be so, but it seems improbable that the relation between the growth force of the femur, and this resistance, could be sufficiently nicely graduated to one another to give such nearly normal bends as are shown in these grafts.

Looking back upon our discussion so far as we have reached, then, we see that the forces which bring about the development of the general form of skeletal elements and of joints must be regarded as inherent in each element, and not as

depending upon differential growth rates, pressures, and muscular pull. That is to say, the general form self-differentiates. To contend that mechanical factors cannot influence the development of bone form would, of course, be absurd. A glance over the figures will show many instances of distortion, which must be due to the action of such factors. All I wish to show is that certain of the mechanical factors which have been put forward as specifically acting to produce bone form, and as essential for its production, do not have the action ascribed to them, but that the form of the elements self-differentiates.

Hoadley pointed out in his works on self-differentiation in the chick that his experiments showed only that differentiation could be attained under the conditions of the experiments, not that it could be maintained. I wish here to follow his lead, and to point out that my experiments in no way suggest that bones could continue their growth and development, and maintain their state of differentiation, throughout life, in absence of a nervous system and of function. A considerable quantity of work, indeed, points rather in the opposite direction. Further it cannot be doubted that the attainment of adult form is dependent upon stance and gait, and upon muscular pull and pressure.

From a consideration of these experiments, then, and of the literature, we arrive at the following view of the development of bone form: (1) The form of the cartilaginous element which precedes the bone self-differentiates, being dependent neither on the presence of contiguous elements, on muscle pull, etc., nor on the action of the nervous system, nor, of course, on function. (2) It is obvious that the bony skeleton is laid down upon the framework already built up by the cartilaginous skeleton, and so is dependent thereon. (3) The form of the skeletal elements of the limbs, as seen at hatching, is the result of the self-differentiation of the different regions of the limb mosaic, but after this period, investigations such as those of Weidenreich and many others show that the future development of bone form is dependent on such factors as stresses and strains due to function, muscular pull and muscular pressure, etc.

It may be of interest to point out what appears to be a difference between the chick and the pig embryos in relation to the deposition of bone. Carey stresses in several papers that the first bone is laid down on the convex side of the femur. In the chick I have noticed very frequently that, where an element is markedly bent, the bone is deposited on the concave side far more than on the convex, as seen in the grafts shown in Figs. 5*a*, 9*c*, 12*a*, 22, 31*a*, while in straight elements it is deposited about equally on each side. One gleans a possible explanation of this from H. B. Fell's paper (1925). Miss Fell states that the membranous fibroblastic layer (periosteum) becomes drawn away from the centre of the long bones by enlargement of the ends of the diaphysis. It seems probable that the deposition of bone on the concave sides of the grafts may be due to the periosteum being drawn away from the centre on the concave side by the bend of the extremities, acting in the same way as the diaphysis in the normal bone.

Abnormalities.

The purpose of this section is to discuss certain abnormalities of particular interest. It is not intended to deal with all the more abnormal specimens, but only with those which, while they have "taken" as grafts and undergone a certain amount of differentiation, have yet failed to develop into well-recognizable limbs or parts of limbs. Such cases are shown in Fig. 4, a little nodule of cartilage which originated from an entire but considerably damaged anterior bud of a four-day chick; Fig. 15*a* (the basal half of a posterior bud, of a four-day donor), another

little nodule of cartilage; Fig. 40*a* (basal third of a posterior bud of a five-day donor) which shows a little better differentiation of form, and is apparently an attempt at a femur; Figs. 8*a*, 8*c* (basal and apical halves of a four-day donor) which have each attained to the form of long thin rods of cartilage; Fig. 7*a* (basal half of a posterior bud of a four-day donor), which consists of three long rods, each larger than the rods seen in Figs. 8*a*, 8*c*, but not really very much more advanced. This latter case provides us with a transition to the normal form. All the specimens mentioned agree in showing development of cartilage, i.e., histological differentiation, with little or no differentiation of form. The reasons for their failure to develop further are not, of course, definitely known, and are probably various. That shown in Fig. 4 originated from a considerably damaged bud, and very probably this is sufficient explanation of its failure to develop more satisfactorily. As regards the other specimens, one can imagine a number of possible factors, chiefly to do with conditions as a graft, such as poor vascularization, excessive cellular reaction on the part of the host, etc. Certain it is that these grafts have not failed to develop because of lack of "potency", i.e., lack of the ability to self-differentiate, since other buds and fragments of buds, of the same ages and younger, have shown themselves able to form well-developed limbs and parts of limbs. But what interests us more particularly is not the reason for the failure to develop, but the lessons we may learn as to the relations between growth, histological differentiation, and differentiation of form. We know (*a*) in no case has a bud or part of a bud undergone extensive growth without accompanying differentiation, histological at least. (*b*) The failure of development of form in the abnormal specimens above cited, and especially those shown in Figs. 4 and 15*a*, tell us that histological differentiation can take place in the buds without concomitant differentiation of form. A rounded nodule can hardly be said to have undergone differentiation of form. (*c*) Whenever a graft grows to any considerable size it always undergoes differentiation both histological and of form, even though that form may be abnormal, as we have seen in Fig. 5*a*, which, originating from an entire posterior bud has formed no structure in the least resembling an entire limb, but merely a bent bar of cartilage with some bone.

GRAFTS FROM THE TWO-DAY CHICKS. (Nos. 60-66, Figs. 47-53.)

It should be emphasized at the outset that the work discussed here and described earlier in this paper should be regarded as a preliminary report only. It is included in this paper in order to make the latter as complete a report as possible of the present state of my investigations, and because it is possible that circumstances may prevent my proceeding further with the work.

The object of this series of experiments was to find the earliest stage and the smallest fragment from which a limb, or a definite and obvious attempt at a limb, will differentiate. It is hoped that it will ultimately be possible to find a stage at which tissue presumptive for limb will, when grafted alone, fail to develop, while if some other part of the chick be included in the graft, development will occur. This would give us a lead for the investigation of the factors concerned in the *determination* of limb tissues. This stage, however, has not yet been found, the experiments not having been, as yet, performed using a sufficiently young donor.

The specimens obtained so far from fragments of two-day chicks have all been very abnormal, as a reference to the descriptive part of the paper and to Figs. 47-53 will show. This is so much the case that it has seemed necessary to fix some kind of a criterion whereby a limb, or rather the result of an attempt to form a limb, could be recognized. It has seemed fair to recognize as an attempt to form

a limb any structure consisting of cartilage originating from presumptive limb tissues and showing some kind of attempt, however poor, to differentiate in form into something suggestive of a limb. Considering that some of the grafts originate from little pieces of the lateral tissues of chicks behind the somite regions, grafted into a most abnormal situation, it would not be reasonable to require a well-formed limb as a criterion. Examination of the figures will, I think, convince the reader that the criterion I have adopted has not been stretched beyond reasonable limits.

A study of the descriptive part of the paper will show that structures which we are justified in regarding as limbs or attempts at limbs have been developed from the following kinds of grafts (it should here be stated that the region of the chick concerned in fore limb formation is that including somites 17-19, and concerning posterior limb formation is that including somites 26-32. Lillie, 1908, p. 184).

No. 60 (Fig. 47).—From a fragment across the chick, containing therefore all the anlagen of the region, from somites 11 to 20 or 21, of a chick having 25 somites. It thus contains the region concerned in the development of the wing.

No. 61 (Fig. 48).—From a fragment right across the chick, from somite 20 right to the end of the chick, which had 23 somites. The graft thus contained three somites belonging to the region between wing and leg, while it contained the leg region in the posterior part of the chick where somites had not developed at the time of grafting. It also contained, of course, the axial region and all its anlagen.

No. 62 (Fig. 49).—From a fragment right across the embryo and containing somites 23 to the end of the chick. Thus it contained three somites between wing and leg, and the leg region in the posterior part of the embryo where somites had not yet developed with the exception of somite 26. It is thus essentially similar to the last, and like it, contained the axial region. The chick had 26 somites.

No. 63 (Fig. 50) contained no axial organs but consisted of a lateral piece containing somites 13-22, the donor having 22 somites. Thus it contained the brachial region at a stage when somites had already developed, and any anlagen that may have been present in this region, such as somites.

Nos. 64-66 (Figs. 51-53) may be grouped together, being all of the same type. Details will be found in the descriptive part. They all consisted of lateral pieces like that used in No. 63, but with the difference that they were taken, not from the somitic region, but from the more posterior region where lies the anlage of the leg, and where, at the stage used, no somites had yet developed.

These last three grafts show us the extreme case of self-differentiation of the limbs yet obtained. The regions grafted were almost certainly without any nervous elements (see below) and without any region of the embryo upon which the development of limbs could be dependent, except the somites (or rather the tissues which later give rise to them), the endoderm and the ectoderm. In future experiments it may be possible to eliminate these, but for the present we must be content to see what little light is shed upon the matter from the literature.

Here I must state that I have most unfortunately been unable to see an important paper by Lillie (1904) and have had to rely upon an abstract made two or three years ago in England. So far as I can judge from my brief abstract, however, this paper does not seem to give information on our present problem, but of this I must leave others to judge. Byrnes (1898) found that the normal development of the posterior extremities in both *Amblystoma* and *Rana* is independent of the presence of the muscle plates of the limb region, while Lewis (1910)

showed that while extirpation of the muscle plates in the limb region of *Amblystoma* produces defects in the lateral and ventral musculature, it has no effect on the limbs. This has been corroborated by Detwiler (1918). The latter author, in the same paper, showed that at the stage of open medullary folds, the limb anlagen of *Amblystoma* are already determined and can be transplanted, while Harrison (1918) has shown that the ectoderm covering the limb buds of *Amblystoma* is not specific and does not, therefore, induce the formation of the bud. The active centre of differentiation is the mesoderm of the bud, which can form a limb even when covered with ectoderm not normally involved in limb development.

Arguing, then, from the Amphibian to the chick, one would not expect the development of the limb to be dependent upon the presence of either the somites or the ectoderm which happens to overlie it. Further experiments will probably show development of the limbs in the absence of somites or of the cells destined to form them.

Detwiler's experiments show that in the stage of open medullary folds the limb anlagen of *Amblystoma* have already received their definite determination, while my experiments show that the anlagen of the posterior limbs of the chick are already determined long before the appearance of the actual bud and before the stage of formation of somites in that region. Absolutely nothing is known as to the factors concerned in the determination, but a possible clue may lie in the work of Geinitz (Spemann, 1925, no reference to Geinitz given) who showed that a piece of *Triton* archenteron, transplanted into the cleavage cavity of another embryo at the onset of gastrulation, came to lie under the ectoderm, and there induced the formation of a secondary medullary plate, so that apparently the archenteron is itself an organizer for the nervous system. Possibly it may be so also for the limbs in the chick. At any rate it gives us a clue to work on.

It should be stated here that the material from the two-day chicks is not sufficiently normal for us to be able to say that either a wing or a leg has developed from the graft. While this is perhaps due merely to the abnormalities enforced upon the limb by the condition of life as a graft, it may mean that the limb rudiments at that stage have received their determination to be limbs, but that the distinction between wing and leg, clearly present at three days, has not yet arisen. This question is one which can only be answered by future investigations, but it is at any rate possible that the reason for the slight differentiation attained by these grafts may be found in Hoadley's idea of dichotomic segregation of potencies. In the absence of further experiments, speculation is of little use here.

The Influence of the Nervous System.

It would naturally be expected that the nervous system would take an important part in development, acting as an integrator, just as it does physiologically in the adult, and various workers have contended that this is indeed the case. The experiments I have described show conclusively, however, that so far as the limbs of the chick are concerned no nervous influence is concerned in their development, at least from the stage of the early limb bud of the three-day chick onwards. The cut which separates the limb buds from the body of the chick passes well lateral of the spinal cord and of the sympathetic chain, and consequently the only nervous elements which can be contained in the graft are the axons of nerve cells, and these degenerate very shortly after the graft is made.

The same applies to certain of the grafts from two-day chicks, but here we come up against a difficulty. In making the cut which separates such grafts as Nos. 63-66 (Figs. 50-53), the knife must pass between the somites and the spinal cord. Now it is always easy to be certain that the whole of the spinal cord is absent from the graft, but there remains the possibility that spinal ganglia or ganglia of the sympathetic chain, if present, might have been included in the graft. We have, therefore, to consider the question, whether or not these structures were present in this region of the chick when the graft was made.

According to Held (1909) and Cajal (1890) the first outgrowth of nerves, at the anterior end of the chick, begins on the third day. This is the day on which the grafts were made, but they originated from the posterior end (I refer especially to Nos. 64-66) and, since the nerves at this end develop later than those at the anterior end, it is very improbable that the limb anlagen had at that time received any innervation. Motor nerves especially seem to be definitely excluded, since Held found that they did not originate until 35 somites. As regards the possible inclusion of spinal ganglia in the grafts, examination of Figs. 107-110 of Lillie (1908) will show that the neural crests at any rate might possibly have been included, although it must be remembered that these figures show sections in the somitic region, while the grafts we are discussing (Nos. 64-66) originate from behind this region, where the neural crests would be in an earlier stage of development and located more dorsally from the spinal cord, in a position where it would be less likely that they would be included in the grafts. It is, however, possible that the neural crest might have been so included (if it avoided complete destruction by the knife).

Perhaps more important than either the dorsal ganglia or the spinal roots is the sympathetic chain, since Schotté (1922) has shown its influence in regeneration of the limbs of *Triton*. In the chick Kuntz (1910) finds that the primary sympathetic trunks arise about the beginning of the fourth day of incubation as a pair of cell columns lying along the sides of the aorta and along the dorsal surfaces of the carotid arteries, i.e., in a position and at a time when they could not possibly be included in any of my grafts. By the close of the sixth day they have almost disappeared, while ultimately they vanish altogether, becoming resolved into the ganglia and nerves constituting the prevertebral and the peripheral sympathetic plexuses. Now, since these trunks may be derived, at least partly, from the spinal ganglia (it seems still to be disputed), and since we have seen that there is some possibility that the spinal ganglia, or rather the neural crests, might be included in the grafts, we cannot be sure that the primary sympathetic trunks may not have developed in the grafts and given rise to some kind of sympathetic plexus. The secondary trunks do not arise until the sixth day, but they again might be included in the grafts, having originated there from the neural crests. Thus we see that grafts Nos. 64-66 might possibly contain a complete sympathetic apparatus, and dorsal ganglia, but that this is very improbable, while they could never have received any motor innervation from the cord.

Turn now to the grafts from three-day chicks, Nos. 57 and 58 (Figs. 45*a*, 45*b*) and No. 59 (Fig. 46*a*). It is possible, but again unlikely, that these buds might have received, before grafting, motor and sensory nerves from the cord and spinal ganglia, but, since grafts could not possibly have contained either the spinal ganglia or the neural crests, or the primary sympathetic trunks, while the secondary trunks had not yet originated, they could not possibly have received, before grafting, or developed after grafting, any sympathetic innervation.

Thus while neither the grafts from two-day chicks, nor those from three-day chicks can be said completely to exclude all conceivable nervous influence, the two do so between them, for while the former might develop under the influence of included sympathetic elements and spinal ganglia, the latter might have received motor or sensory nerves from cord and ganglia before grafting (certainly none after grafting).

We may therefore draw the following conclusions: (1) The bud of the three-day chick can complete its development into a limb without any further nervous influence. (2) The limb anlagen from before the bud stage can develop into a limb without the influence of motor nerves from the spinal cord, and probably without any other nervous influence. (3) The bud of the three-day chick attains the bud stage without any influence from the sympathetic system, and it is very improbable that it has received any other innervation either.

While believing that the limb of the chick developes without receiving any "formative stimulus" from the nervous system, this does not mean that I wish to deny the influence of the latter in regeneration (Schotté, 1922) nor its possible importance in maintaining the form of bones, etc.

Weiss (1925) has recently elaborated a theory of "Gestaltungstonus", according to which cells, in order to undergo differentiation, must be in a certain state of tonus. If they are not in this state, they can proliferate but not differentiate. This conception was based upon his belief in the importance of the sympathetic nervous system in the regeneration of the limbs of *Urodela*, which has been experimentally confirmed by Schotté. Since my experiments show conclusively the ability of the limb bud of the chick to develop without any sympathetic or other nervous supply, at least from the three-day stage onwards this conception seems unnecessary here.

In conclusion, it gives me the greatest pleasure to acknowledge the debts of gratitude which I owe to a number of people for the generous assistance they have accorded me during the course of this work. In the first place I must acknowledge the assistance I have received from my wife, who acted as my assistant in all experiments and in the preparation of the paper. To Dr. A. B. Walkom I am very deeply indebted for the considerable trouble to which he put himself in order to ensure me a regular supply of most excellent eggs. Professor Launcelot Harrison has been most kind while I have been working in his department, rendering always every assistance in his power, while to Professor A. N. Burkitt, Dr. I. M. Mackerras, Mr. A. J. Nicholson, and many others, I am indebted for many helpful suggestions and advice. Finally I have to acknowledge that this work was done with the assistance of a generous grant from the Society, and I must express my deep gratitude to the Society for assisting me in this way.

SUMMARY.

(1). The limb buds of the chick, from three days' incubation onwards, or fragments of the buds, when grafted on to the chorio-allantoic membrane of older chicks, are able to continue their growth and differentiation, and may reach an advanced stage of development, attaining a form which is extraordinarily close to the normal. That is, the limb bud is a self-differentiating system.

(2). Grafts of fragments of limb buds of chicks at three, four and five days' incubation show that the bud at these stages is a mosaic structure, since fragments developing as grafts will self-differentiate to form those structures which they

would form in normal development but no more, subject to the statements made in sections (3) and (4) of this summary.

(3). It is probable that some slight ability to regulate is possessed by the limb buds at four and five days, but this is very slight, and is probably dependent upon the condition of the boundaries as hypothecated in the next section. The evidence from the buds of three-day chicks is insufficient to allow us to say whether this is true of them also, but this would be indicated by general probability.

(4). Evidence is given favouring the view here put forward, in a tentative manner, that the boundaries between regions of the mosaic in the limb bud is not a hard and fast line, but a belt of tissue which is probably of a more or less indifferent nature, the fate of which is determined by which of the contiguous mosaic regions obtains control of it. This hypothesis is compared with the "Wirkungskreis" theory of Weiss.

(5). The following conclusions are drawn with reference to the development of bone form (fragments of buds giving origin to single skeletal elements whose form is very close to normal):

(*a*). The form of the cartilaginous elements which precede the bone self-differentiates, not being dependent on the presence of contiguous elements, the action of the nervous system or function, nor probably on muscle pull, etc. (*b*). It is obvious that the bony skeleton is laid down upon the framework already built up by the cartilaginous skeleton, and so is dependent thereon. (*c*). The form of skeletal elements of the limbs, as seen at hatching, is the result of the self-differentiation of the different regions of the limb mosaic, but after this period investigations such as those of Weidenreich and of many others show that the further development of bone form is dependent on such factors as stresses and strains due to function, muscular pull and muscular pressure, etc.

(6). It is shown from grafts of fragments of two-day chicks, before the limb bud has appeared, that the anlagen of the posterior limb are already determined at a stage before somites have developed in the limb region. The reservation is made that the endoderm contained in the graft may possibly have some function in determining the limb tissues. See section (7) for the nervous system.

(7). The following conclusions are drawn with reference to the possible action of the nervous system in development:

(*a*). The bud of the three-day chick can complete its development into a limb without any further nervous influence. (*b*). The limb anlagen from before the bud stage can develop into a limb without the influence of motor nerves from the spinal cord, and probably without any other nervous influence. (*c*). The bud of the three-day chick attains the bud stage without any influence from the sympathetic nervous system, and it is probable that this applies also to both kinds of spinal nerves.

It may therefore be concluded that in all probability the nervous system is not concerned in the development of the limb, while it is certainly not so concerned after the third day.

(8). From a study of some of the less successful grafts we conclude:

(*a*). A grafted bud cannot undergo any extensive growth without accompanying differentiation, histological at least. (*b*) Histological differentiation can take place in a grafted bud without concomitant differentiation of form. (*c*). Whenever a graft grows to any considerable size it always undergoes differentiation both histological and of form, though that form may be very abnormal.

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UPPER PERMIAN INSECTS OF NEW SOUTH WALES.

PART II. THE ORDERS MECOPTERA, PARAMECOPTERA AND NEUROPTERA.

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(Plates xv-xvi and eighteen Text-figures.)

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The three Orders dealt with in this Part are closely allied, and are the only representatives of the Orders comprising the "Panorpoid Complex" known to have been in existence in Palaeozoic times. The oldest of the three Orders is the Mecoptera, found fairly abundantly in the Lower Permian of Kansas, U.S.A., no less than six genera and fourteen species being known from those beds, while an even older ancestral type, *Metropator pusillus* Handl., from the Lower Pottsville beds in the Upper Carboniferous of America, is one of the eight oldest insect wings yet discovered, and is definitely Mecopterous in structure.

The allied Order Paramecoptera is known only from the Upper Permian of Belmont, N.S.W. It is a side-branch of the original Mecopterous stem, and has given rise to the three recent Orders Trichoptera, Lepidoptera and Diptera, the latter through the transitional group of Triassic forms which I have named Paratrichoptera, but which Dr. Crampton prefers to call Protodiptera.

The Neuroptera are considered by many students at the present day, on the grounds of comparative morphology, to be older than the Mecoptera. Nevertheless, the evidence is fairly complete by now that they originated from *Merope*-like forms within the Order Mecoptera, and it must be assumed that the Palaeozoic ancestors of the Meropidae were sufficiently generalized in their life-histories and in the form of their mouth-parts to have given origin to the three distinct groups, Raphidioidea, Sialoidea and Planipennia, which now constitute the Order Neuroptera. The Lower Permian *Protomerope permiana* Till. is the oldest known type of the *Merope* group of genera, and its direct descendants can be recognized in the Upper Permian *Permomerope*, n.g., described in this Part, in an as yet undescribed form recently discovered in the Middle Trias in Australia, in the Upper Triassic genus *Archipanorpa*, and in the recent American genera *Merope* and *Notiothauma*. These forms have been grouped together by me into a distinct Suborder Protomecoptera, characterized by the widening of the costal space and the possession of a complete series of costal veinlets such as is found also in the Neuroptera.

The oldest known true Neuroptera do not appear until the Upper Permian. Only one species, *Permithone belmontensis* Till., has so far been described, but several new genera and species are added in this Part. *Permithone* is derivable from forms like *Protomerope* simply by the development of terminal twiggings

to the veins, by the change in the type of branching of Rs from dichotomic to pectinate, and by the addition of a distal pectinate series of branchlets to the originally simple Cu_1.

The following is a list of the genera and species dealt with in this Part:

Order Mecoptera.

Suborder Eumecoptera.

Family **Mesochoristidae.**

Genus 1. PERMOCHORISTA Till.

1. *Permochorista australica* Till. Genotype. Belmont.
2. *Permochorista mitchelli* Till. Belmont.
3. *Permochorista jucunda*, n. sp. Belmont.
4. *Permochorista collinsi*, n. sp. Belmont.
5. *Permochorista pincombei*, n. sp. Belmont.
6. *Permochorista angustipennis*, n. sp. Belmont.
7. *Permochorista osbornei*, n. sp. Belmont.
8. *Permochorista sinuata* Till. Belmont and Warner's Bay.
9. *Permochorista affinis* Till. Belmont.
10. *Permochorista inaequalis*, n. sp. Belmont.
11. *Permochorista belli*, n. sp. Warner's Bay.

Genus 2. CLADOCHORISTA, n.g.

12. *Cladochorista belmontensis*, n. sp. Genotype. Belmont.

Genus 3. PARACHORISTA, n.g.

13. *Parachorista pincombeae*, n. sp. Genotype. Belmont.
14. *Parachorista warnerensis*, n. sp. Warner's Bay.
15. *Parachorista splendida*, n. sp. Belmont.
16. *Parachorista bairdae* (Till.). Belmont.

Suborder Protomecoptera.

Family **Protomeropidae.**

Genus 4. PERMOMEROPE, n.g.

17. *Permomerope australis*, n. sp. Genotype. Belmont.

Genus 5. APHRYGANONEURA, n.g.

18. *Aphryganoneura anomala*, n. sp. Genotype. Belmont.

Order Paramecoptera.

Family **Belmontiidae.**

Genus 1. BELMONTIA Till.

1. *Belmontia mitchelli* Till. Genotype. Belmont.

Family **Parabelmontiidae.**

Genus 2. PARABELMONTIA Till.

2. *Parabelmontia permiana* Till. Genotype. Belmont.

Order Neuroptera.

Suborder Planipennia.

Family **Permithonidae.**

Genus 1. PERMITHONE Till.

1. *Permithone belmontensis* Till. Genotype. Belmont.
2. *Permithone oliarooides*, n. sp. Belmont.

Genus 2. PERMORAPISMA, n.g.

3. *Permorapisma biserialis*, n. sp. Genotype. Belmont.
4. *Permorapisma triserialis*, n. sp. Warner's Bay.

Genus 3. PERMOSMYLUS, n.g.

5. *Permosmylus pincombeae*, n. sp. Genotype. Belmont.

Genus 4. PERMOPSYCHOPS, n.g.

6. *Permopsychops belmontensis*, n. sp. Genotype. Belmont.

The photographs from which Plates xv-xvi have been prepared were taken by Mr. W. C. Davies, Curator of the Cawthron Institute, to whom my best thanks are due.

Order Mecoptera.

Suborder Eumecoptera.

Family Mesochoristidae.

This family is distinguished by the six-branched media of the forewings; in the hindwings, this vein has either four or five branches only. Rs has four or more branches. The three genera found in the Upper Permian of New South Wales may be distinguished as follows:

1. Sc with a series of distal veinlets; stalk of R_{2+3} shorter than that of R_{4+5} .... Genus 3. *Cladochorista*, n.g.
   Sc without a series of distal veinlets; stalk of R_{2+3} not shorter than that of R_{4+5} 2
2. Stalk of R_{2+3} much longer than that of R_{4+5}; Rs with only four branches, or at most with an additional small terminal fork on R_2 .... Genus 1. *Permochorista* Till.
   Stalks of R_{2+3} and R_{4+5} both short, subequal; Rs with five or more well developed branches .... Genus 2. *Parachorista*, n.g.

Genus 1. Permochorista Till.

(These Proceedings, 1917, xlii, p. 732.)

This genus is the dominant one of the Order in the Belmont and Newcastle Beds. Fragments of its wings are more commonly met with than any other fossil insects there, and I have examined more than fifty such specimens from Mr. Mitchell's and Mr. Pincombe's collections, besides several collected by myself. Most of these are too incomplete to place specifically, particularly as this genus, like the Liassic *Orthophlebia*, has a considerable variation in the details of its venation, and the cross-veins, when distinguishable, vary with each individual wing. The only safe characters to rely upon when defining species are the form of Sc and Cu_1, the structure of the cubito-median Y-vein and anal veins, and marked features of shape or colour-pattern. The form of the media of the forewing is very constant throughout the genus, the extra forks being developed on M_2 and M_4, so that the six branches of this vein are M_1, M_{2a}, M_{2b}, M_3, M_{4a} and M_{4b}. The lengths of the radial forks are not altogether reliable specific guides. In the hindwing the media appears to be usually only four-branched, but an extra fork appears on M_4 in one species; also the amount of approximation or fusion between Cu_2 and 1A is a good specific character.

Genotype, *P. australica* Till., Upper Permian of Belmont, N.S.W.

The known species may be distinguished as follows:

1. Forewings. M with six branches 2
   Hindwings. M with four or five branches 10
2. Distal end of Cu_1 either straight or slightly curved convexly to M above it 3
   Distal end of Cu_1 curved concavely to M above it 7
3. Weak veinlets present distally both on Sc and R_1 .... *P. mitchelli* Till.
   No such veinlets present 4
4. Base and anal area of wing exceptionally narrowed; Cu_1 ending very close to M_{4b} .... *P. angustipennis*, n. sp.
   Base and anal area of normal width; Cu_1 ending not so close to M_{4b} 5
5. Wing broadly rounded apically .... *P. pincombei*, n. sp.
   Wing of more oval shape, less broadly rounded apically 6
6. Cu_1 straight; M_1 upcurved basally .... *P. australica* Till.
   Cu_1 bent about its middle; M_1 straight .... *P. jucunda*, n. sp.
7. Wing with strongly mottled colour-pattern of fuscous and hyaline .. *P. collinsi*, n. sp.
   Wings without any marked colour-pattern 8

8. Concave distal portion of Cu_1 strongly curved and connected at its origin with M_4 by a cross-vein which bends the latter vein markedly at its junction with it; M_5 shorter than basal piece of Cu_1 9
   Concave distal portion of Cu_1 only weakly curved and not connected with M_4 as above; M_5 and basal piece of Cu_1 about equal .... *P. osbornei*, n. sp.
9. Wing 8 mm. long, with pterostigma and fork of Sc long .... *P. sinuata* Till.
   Wing 6·6 mm. long, with much shorter pterostigma and fork of Sc .... *P. affinis* Till.
10. M five-branched; Cu_1 slightly concave to M_4 distally .... *P. osbornei*, n. sp.
   M four-branched. Cu_1 straight or slightly curved away from M_4 distally 11
11. Stalks of R_{4+5} and M_{1+2} short .... *P. inaequalis*, n. sp.
   Stalks of R_{4+5} and M_{1+2} long, especially the latter (fork of R_{2+3} very short, with R_2 closely approximated to R_1) .... *P. belli*, n. sp.

1. Permochorista australica Till.

(These Proceedings, 1917, xlii, p. 733.)

The type wing of this species is incomplete, the base, anal area and costa as far as end of Sc being absent. All the branches of R and M are present, also an absolutely straight Cu_1, but the cubito-median Y-vein is missing. $R_{2,3}$ and $M_{1,2}$ have their stalks about as long as their forks; the stalks of R_{4+5} and M_{3+4} are much shorter.

Type: *Holotype forewing*, Specimen No. 24 in Mr. Mitchell's collection, from Belmont.

2. Permochorista mitchelli Till.

(These Proceedings, 1917, xlii, p. 734.)

The type wing of this species is also incomplete, the apical fourth and a portion of the base being missing. Sc is simple, and both Sc and R_1 have a series of weak veinlets running to costa. The forkings of Rs and M are similar to those of *P. australica* Till., but the stalks of R_{4+5} and M_{3+4} are shorter.

Type: *Holotype forewing*, Specimen No. 26 in Mr. Mitchell's collection, from Belmont.

3. Permochorista jucunda, n. sp.

(Text-fig. 1; Plate xv, fig. 1.)

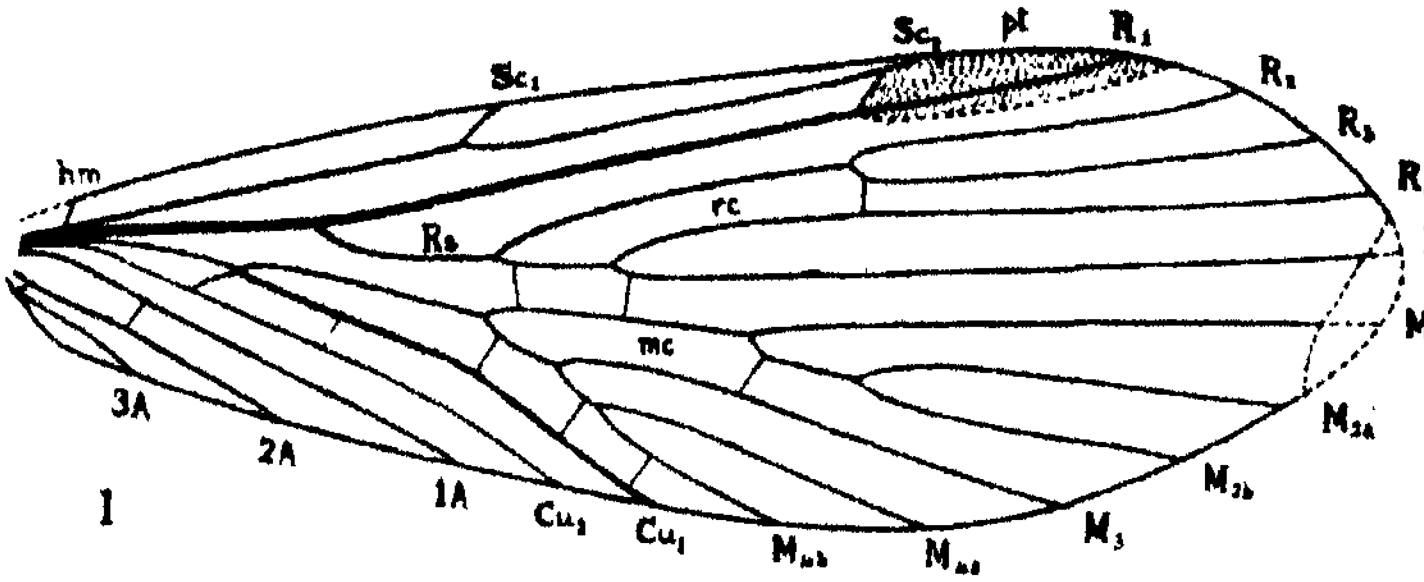
Length 7·3 mm. A practically complete forewing in a perfect state of preservation, only a minute portion at the apex being missing. The impression is that of a right wing; both obverse and reverse were recovered complete. The wing is strongly impregnated with yellowish-brown oxide of iron, making it a conspicuous object on the pale greyish chert of the surrounding rock. The most important specific characters are the forking of Sc at the middle of its length, the bend of Cu_1 slightly towards M about its middle, and the loss of M_5, so that Cu_1 fuses momentarily with M. Cross-veins are entirely absent distally, and are confined to a few in special positions, viz. as struts below and just distad from the origins of R_2, R_{4+5}, R_4, M_1, M_{3+4}, M_{4a} and M_{4b}; there is also a weak cross-vein between Cu_1 and Cu_2 and one between 1A and 2A. The cross-vein below origin of R_2 closes an elongated radial cell (*rc*), while that below origin of M_3 closes a similar but slightly shorter median cell (*mc*), thus indicating the manner in which these cells have become fixed in the more specialized Orders Trichoptera, Lepidoptera and Diptera.

Type: *Holotype forewing*, Specimen No. P.167 (obverse and reverse) in Mr. Pincombe's collection; the obverse has been presented by Mr. Pincombe to the Cawthron Institute Collection, and the reverse to Mr. Mitchell. Found by Mr. Pincombe at Belmont, 31st Oct., 1925.

4. Permochorista collinsi, n. sp.

(Text-fig. 2; Plate xv, fig. 2.)

A nearly complete obverse impression of a forewing, with apex to left; length 8·5 mm., indicating a probable total length of about 9·5 mm. The outstanding feature of this specimen is its strongly marked colour-pattern, which is strongly mottled in fuscous and hyaline, the fuscous being mostly in rectangular blocks tending to become arranged more or less into transverse fasciae. The veins are very stout, particularly R and its branches. Sc is strongly forked distally and Sc_2 is strutted on to R_1 by two oblique cross-veins. $R_{2,3}$ has its stalk



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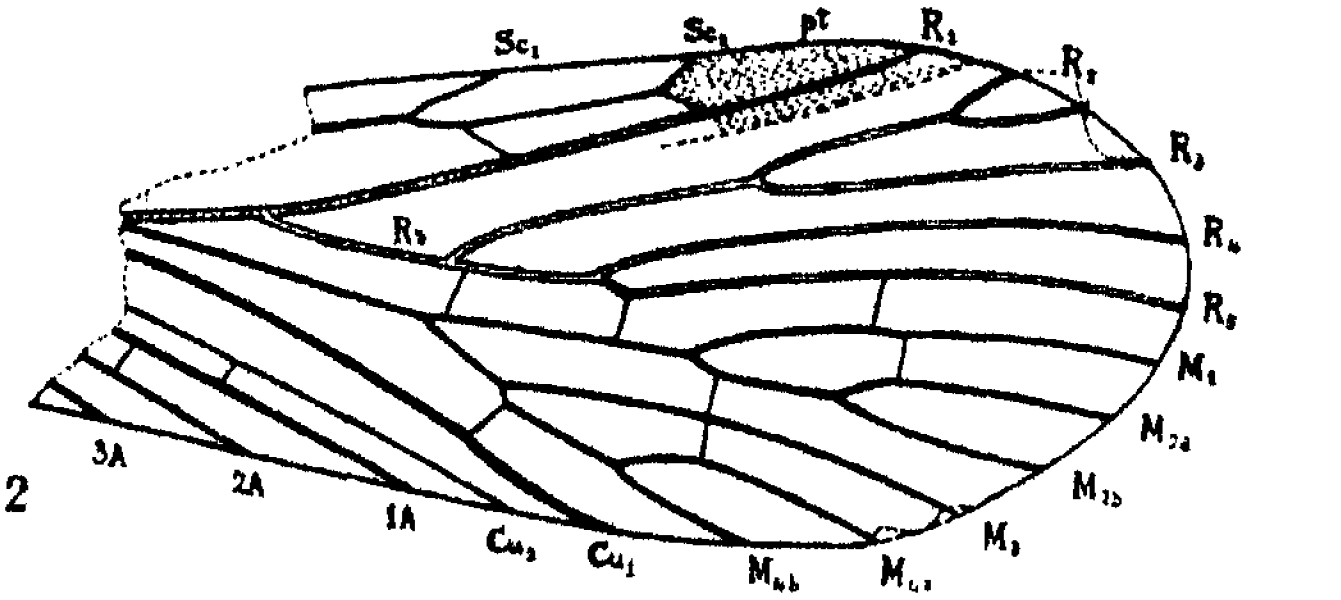

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Text-fig. 1. *Permochorista jucunda*, n. sp. Forewing. Obverse of Specimen No. P. 167. Length 7·3 mm.

Text-fig. 2. *Permochorista collinsi*, n. sp. Forewing, with apex turned to right, and colour-pattern omitted. Specimen No. 116. Length 8·5 mm.

about equal to its fork, and R_2 has an extra distal fork of small size. R_5 is strongly strutted on to M_1 and bent at the cross-vein; M_4 is similarly strutted on to Cu_1 and bent. Cu_1 is slightly concave to M_4 distally. Cubito-median Y-vein missing. Cu_2 converges markedly towards Cu_1 distally. A few cross-veins are present as shown in Text-fig. 2.

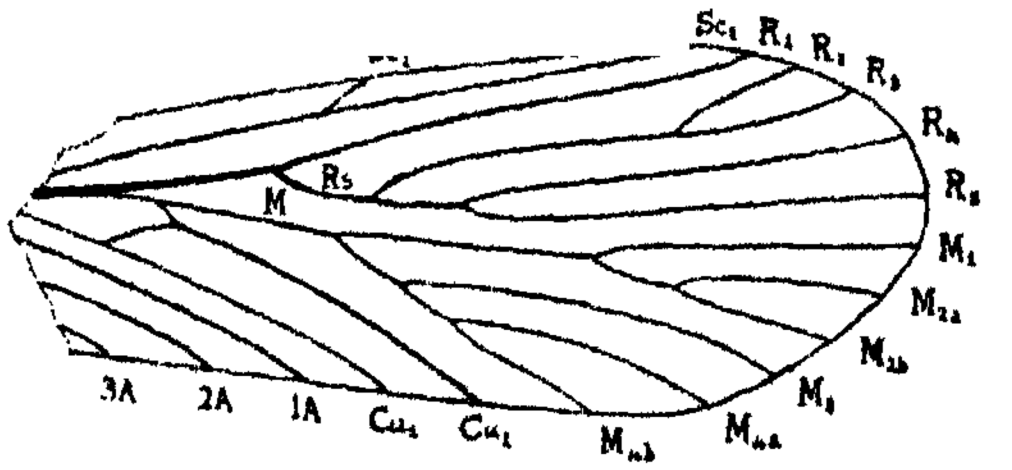
Type: *Holotype forewing*, Specimen No. 116 in Mr. Mitchell's collection; found by Mr. Collins at Belmont and dedicated to its discoverer. It is the most striking and beautiful wing of this genus yet discovered.

5. Permochorista pincombei, n. sp. (Text-fig. 3.)

A nearly complete forewing, 7·2 mm. long; an obverse impression with apex to right. Colour pale greyish on a medium grey chert; venation rather faint. The specific characters are the very long Sc, ending very close to R_1 and forking about middle, the very short fork of $R_{2,3}$ and the well developed cubito-median

Y-vein; also the practically straight Cu_1. No cross-veins can be made out in any part of the wing.

Type: *Holotype forewing*, Specimen No. P.157 in Mr. Pincombe's collection; found at Belmont by Mr. Pincombe in 1925.



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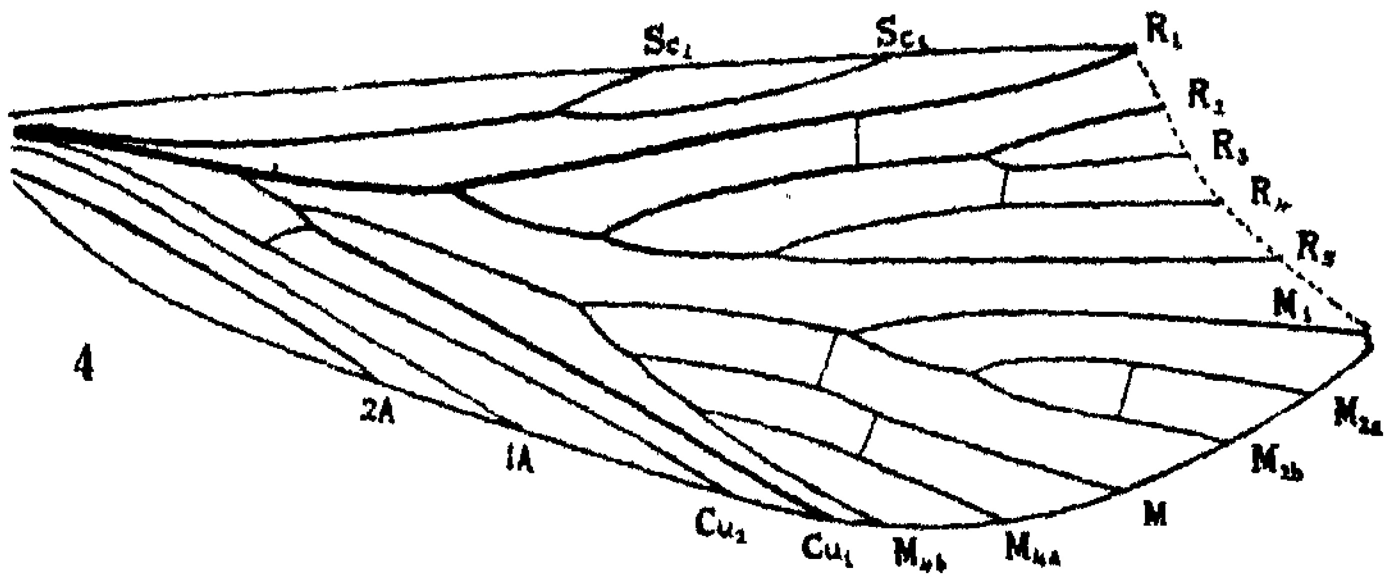

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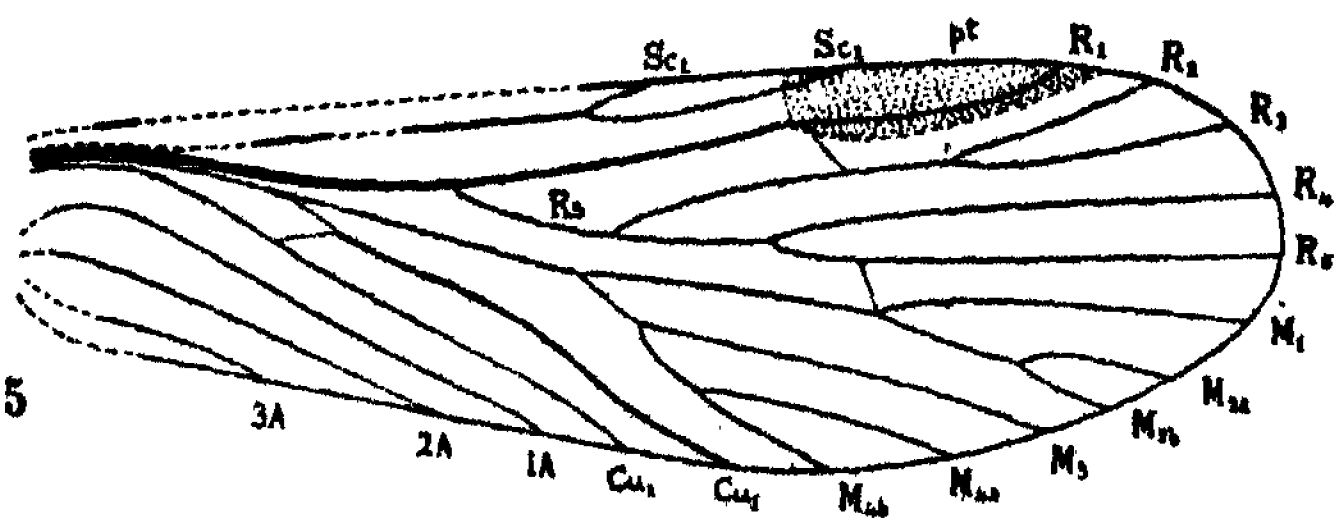

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Text-fig. 3. *Permochorista pincombei*, n. sp. Forewing. Specimen No. P.157. Length 7·2 mm.

Text-fig. 4. *Permochorista angustipennis*, n. sp. Forewing. Specimen No. 91, with apex turned to right. Length 11 mm.

Text-fig. 5. *Permochorista osbornei*, n. sp. Forewing. Specimen No. T1. Length 12 mm.

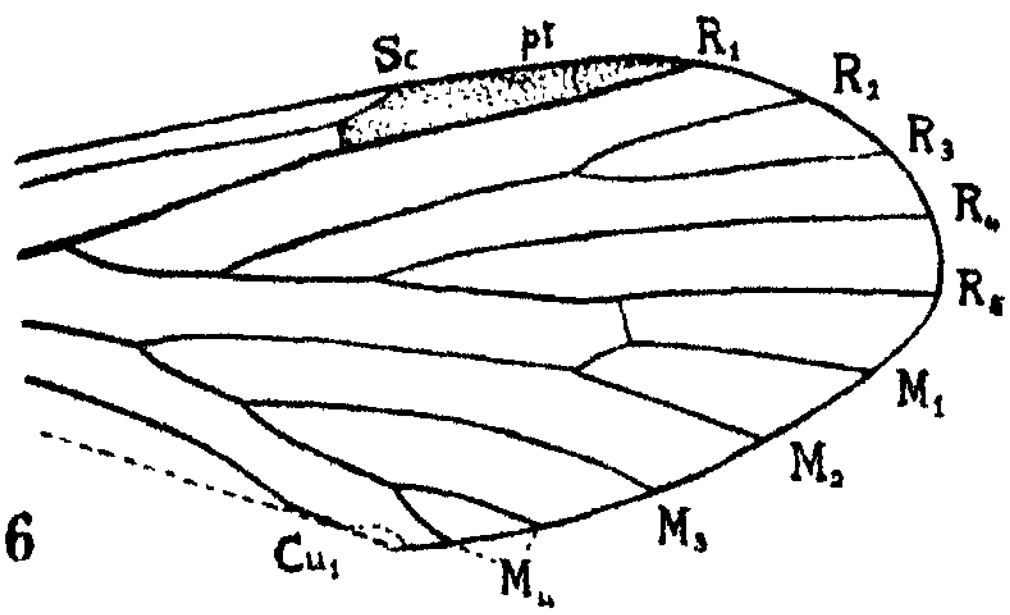
6. Permochorista angustipennis, n. sp. (Text-fig. 4.)

A rather large wing with apex missing; length 11 mm., indicating a total length of at least 12 mm.; an obverse impression with apex to left. Colour greyish on chert of similar colour. The costal margin is very straight and the base remarkably narrowed. Sc strongly forked, the distances between the ends of Sc_1, Sc_2 and R_1 being about equal. Cu_1 straight, very close to M_{4b} distally; Cu_2 also very close to Cu_1. Cubito-median Y-vein small but well-formed, with M_5 shorter than the free piece of Cu_1. Anal area very narrow, with only two anal veins.

Type: *Holotype forewing*, Specimen No. 91 in Mr. Mitchell's collection; found by Mr. Mitchell at Belmont in 1923.

7. PERMOCHORISTA OSBORNEI, n. sp. (Text-figs. 5, 6.)

Forewing: Length 12 mm. A reverse impression with apex to right, greyish-white on chert of same colour; basal half of costa and extreme base of anal area slightly damaged. Sc forked, the distances between the ends of Sc_1, Sc_2 and R_1 about equal; pterostigma large, with R_1 markedly curved within it. Stalk of R_{2+3} longer than its fork. Fork of M_2 small. Cu_1 curved concavely to M_4 distally. Cubito-median Y-vein well developed, its two arms about equal in length. Wing broadly rounded apically, but narrower in the middle than usual in this genus.



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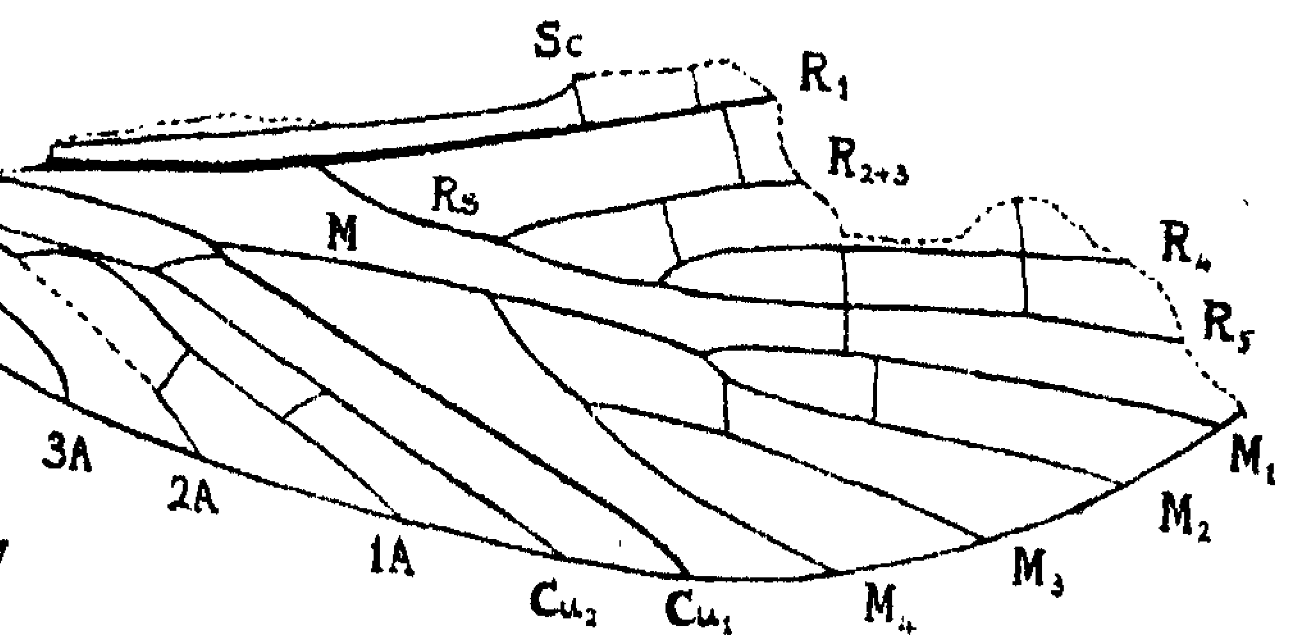

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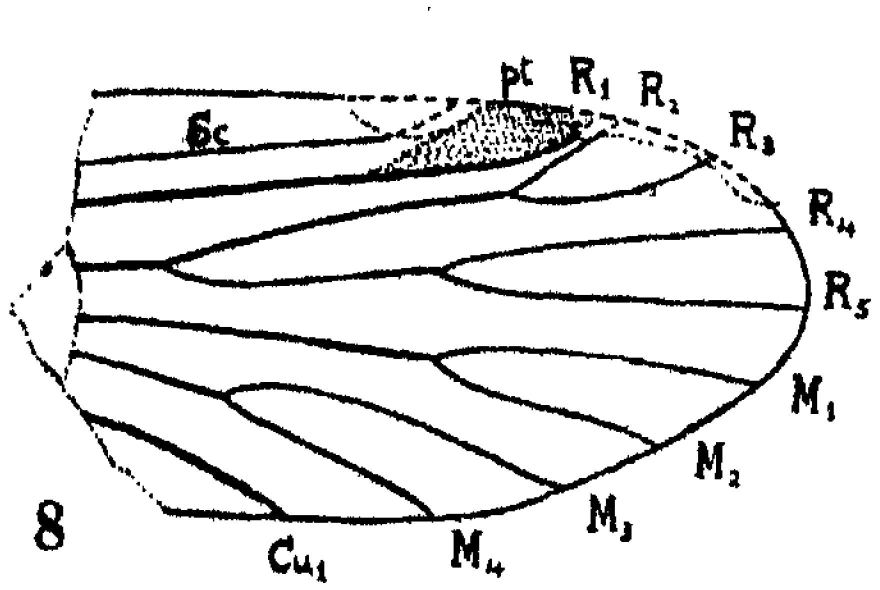

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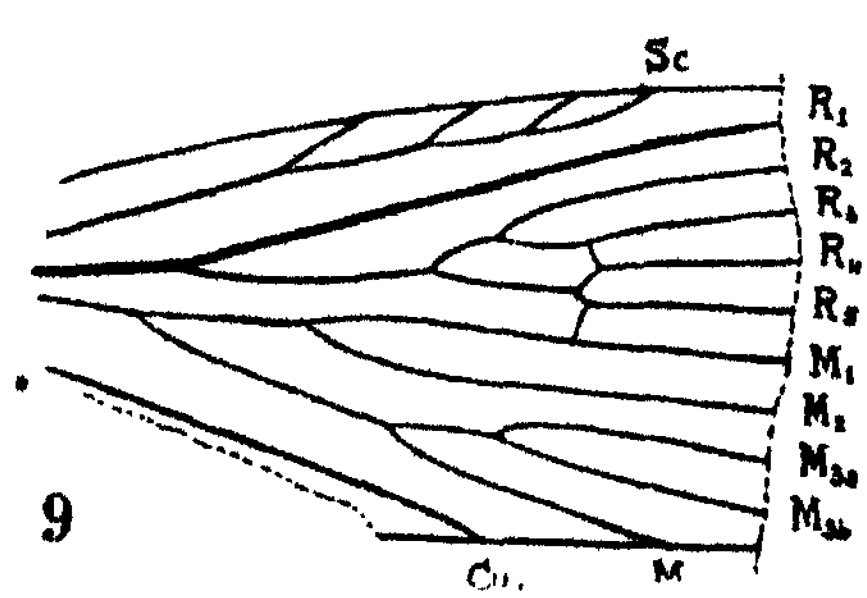

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Text-fig. 6. *Permochorista osbornei*, n. sp. Hindwing. Specimen No. T4. Length 6 mm.

Text-fig. 7. *Permochorista inaequalis*, n. sp. Hindwing. Specimen No. P.154. Length 8·8 mm.

Text-fig. 8. *Permochorista belli*, n. sp. Hindwing. Specimen No. P.187. Length 3 mm.

Text-fig. 9. *Cladochorista belmontensis*, n.g. et sp. Forewing. Specimen No. 96. Length 4 mm.

Hindwing: The apical two-thirds of what appears undoubtedly to be the hindwing of this species is shown in Text-fig. 6. M is five-branched, the extra branch on M_4 being small. Sc is simple (as probably in all hindwings of this genus) and the pterostigma longer and narrower than in forewing. Length 6 mm.

Types: *Holotype forewing*, Specimen No. T1 in Cawthron Institute Collection; found by myself at Belmont, 12th Nov., 1921. *Heautotype hindwing*, Specimen No. T4 in Cawthron Institute Collection; found by myself at Belmont, 12th Nov., 1921, close to the forewing in the same block of chert. Dedicated to Mr. G. D. Osborne of the Department of Geology, Sydney University, whom I first met on the expedition to Belmont at which these two wings were found.

8. PERMOCHORISTA SINUATA Till.
(These PROCEEDINGS, 1922, xlvii, p. 287.)

Type: *Holotype forewing*, Specimen No. 55 in Mr. Mitchell's collection; *paratype*, Specimen No. 51 in same collection. A third specimen of this well marked species has since been found, with apical part of wing missing, by Mr. Pincombe, in a block of dark grey chert from Warner's Bay; label, No. 147, date August 10th, 1925.

9. PERMOCHORISTA AFFINIS Till.
(These PROCEEDINGS, 1922, xlvii, p. 288.)

Type: *Holotype forewing*, Specimen No. P3 in Mr. Mitchell's collection; found by Mr. Pincombe at Belmont.

10. PERMOCHORISTA INAEQUALIS, n. sp. (Text-fig. 7.)

A fragment of a hindwing 8·8 mm. long, reverse impression on greyish chert, with apex to right, and lying rather close to a portion of a frond of *Glossopteris*. Stalk of R_{2+3} long, of R_{4+5} and the two main branches of M rather short. M four-branched. Cubito-median Y-vein with M_5 excessively short. Cu_1 straight except for a slightly curved apex. 1A arches up so as almost to fuse with Cu_2 near base. A few weak cross-veins present, including one at end of Sc and another further distad above R_1.

Type: *Holotype hindwing*, Specimen No. P.154 in Mr. Pincombe's collection; found by him at Belmont in 1925.

11. PERMOCHORISTA BELLI, n. sp. (Text-fig. 8.)

This species is represented by the apical half of a very small wing, the fragment measuring only 3 mm. in length, and indicating a total length of wing of about 6 mm. only. Pterostigma very short, with Sc ending close to it. Rs and M both four-branched, the fork of R_{2+3} very short and R_2 exceedingly close to R_1. Cu_1 almost straight apically. No cross-veins present.

Type: *Holotype hindwing*, Specimen No. P.187 in Mr. Pincombe's collection; found by Mr. W. Bell at Warner's Bay, 12th Dec., 1925, and dedicated to its discoverer.

Genus 2. CLADOCHORISTA, n.g. (Text-fig. 9.)

Sc ending in a series of strong veinlets. Stalk of R_{2+3} very short, shorter than that of R_{4+5}. M with at least five branches, the extra branch being developed on M_2.

Genotype: *Cladochorista belmontensis*, n. sp.

Horizon.—Upper Permian of Belmont, N.S.W.

12. CLADOCHORISTA BELMONTENSIS, n. sp. (Text-fig. 9.)

A fragment of a forewing 4 mm. long, greyish-brown on grey chert, having the apical third, part of the base and all the anal area missing. Cu_1 straight. Cubito-median Y-vein missing. A cross-vein above R_4 close to its origin closes off a rather short radial cell; there is a second cross-vein at same level between R_5 and M_1. On the preserved portion there are four branches to Rs and five to M, but there may well have been further branches on the missing distal portion.

Type: *Holotype forewing*, Specimen No. 96 in Mr. Mitchell's collection; found by him at Belmont in 1924.

Genus 3. PARACHORISTA, n.g. (Text-figs. 10-12; Plates xv, fig. 3; xvi, fig. 4.)

A very distinct genus of the type of *Permochorista*, but distinguished from it at once by the stalks of R_{2+3} and R_{4+5} both being short and more or less equal in length, and by R_{2+3} having more than one fork; the extra fork or forks are developed on R_2, thus foreshadowing the method by which the pectinate arrangement of the branches of Rs has been brought about in the Neuroptera.

Genotype: *Parachorista pincombeae*, n. sp.

Horizon.—Upper Permian of Belmont and Warner's Bay.

I now include within this genus the fragment which I originally named *Archipanorpa* (?) *bairdae* Till. from Belmont. The four known species may be distinguished as follows:

1. Very large wing about 30 mm. long ... *P. bairdae* (Till.)
   Wings under 20 mm. in length ... 2
2. Forewings: Rs with six branches ... 3
   Hindwing: Rs with only five branches ... *P. splendida*, n. sp.
3. R_1 simple; Cu_1 bent concavely to M_4 distally ... *P. pincombeae*, n. sp.
   R_1 distally forked; Cu_1 straight ... *P. warnerensis*, n. sp.

13. PARACHORISTA PINCOMBEAE, n. sp. (Text-fig. 10; Plate xv, fig. 3.)

A well preserved and nearly complete forewing 12 mm. long, with extreme base and anal area missing; reverse impression with apex to left, and obverse with a triangular piece broken away from its middle, on medium grey chert. Sc strongly forked distally, with Sc_2 braced below by a cross-vein on the R_1 not far from its origin. Pterostigma long, with R_1 running straight through it unbranched. First forking of Rs markedly distad from that of M. Stalk of M_{1+2} thrice as long as that of M_{3+4}. Extra branches of M arranged on M_2 and M_4, as in *Permochorista*. Cubito-median Y-vein very strongly developed, but M_5 shorter than free piece of Cu_1. Numerous weak cross-veins in distal portion of wing, and one strong cross-vein about midway between Cu_1 and Cu_2.

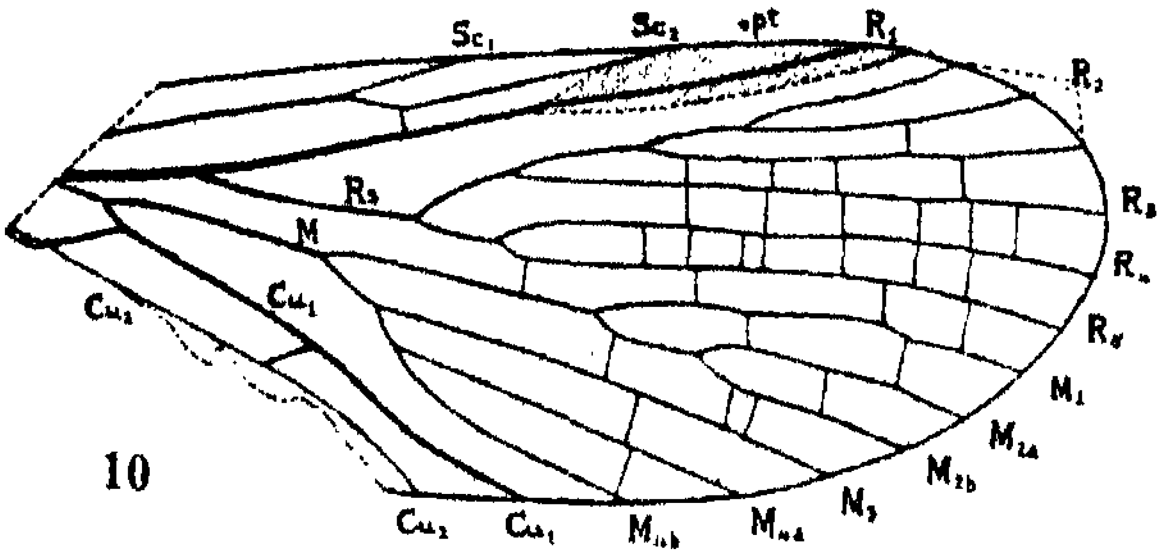
Type: *Holotype forewing*, Specimen No. 83 (reverse) in Cawthron Institute Collection; *holotype counterpart*, Specimen No. 55 (obverse) in Mr. Pincombe's collection; found at Belmont by Mrs. T. H. Pincombe on 12th August, 1923, and dedicated to their discoverer.

14. PARACHORISTA WARNERENSIS, n. sp. (Text-fig. 11.)

A very dark fragment of a forewing, 9 mm. long, on dark grey chert; reverse impression, with apex to left. Base and apex missing. Sc and R_1 both strongly forked distally; the limits of the pterostigma not visible owing to the darkness of the whole wing. The two branchings of R_2 arise closer together than in the previous species. Stalk of M_{1+2} only about half as long again as that of M_{3+4}. Cu_1 straight. Cubito-median Y-vein missing. Portions of Cu_2 and two anal veins

visible. The extra forks of M are arranged on M_2 and M_3, not as in *Permochorista* on M_2 and M_4. Cross-veins apparently absent except for a weak one between R_5 and M_{1+2}.

Type: *Holotype forewing*, Specimen No. P.164 in Mr. Pincombe's collection; found at Warner's Bay in 1925.



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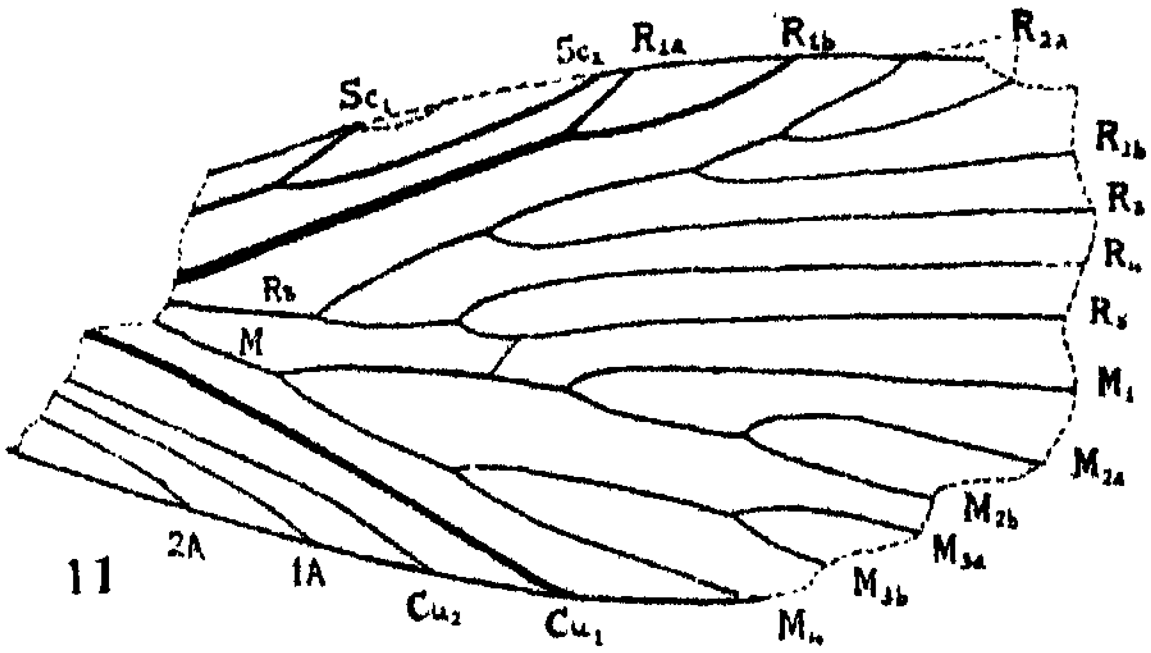

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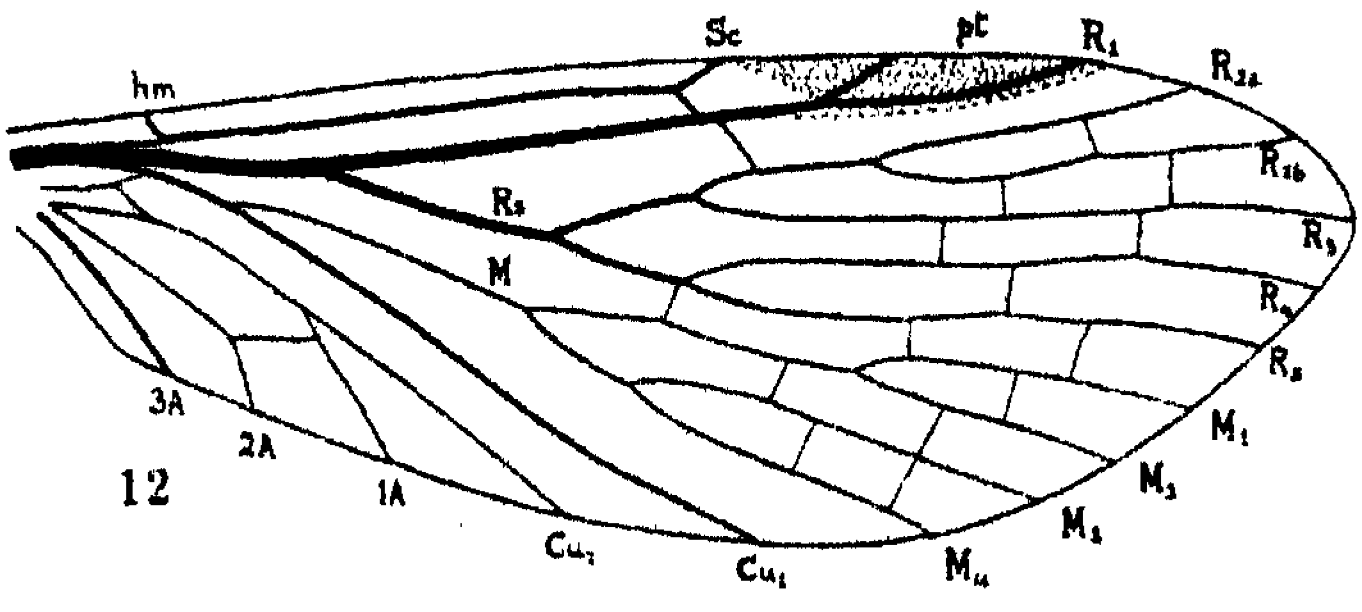

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Text-fig. 10. *Parachorista pincombeae*, n.g. et sp. Forewing, with apex turned to right. Specimen No. 83. Length 12 mm.

Text-fig. 11. *Parachorista warnerensis*, n. sp. Forewing, with apex turned to right. Specimen No. P.164. Length 9 mm.

Text-fig. 12. *Parachorista splendida*, n. sp.. Hindwing, with apex turned to right. Specimen No. 107. Length 15 mm.

15. PARACHORISTA SPLENDIDA, n. sp. (Text-fig. 12; Plate xvi, fig. 4.)

A perfect reverse impression of a hindwing, with apex to left; length 15 mm.; colour pale grey on chert of same colour. Sc forked distally, the posterior branch fusing with R_1. R_1 forked within the pterostigma (the veinlet forming the fork

may be the free distal portion of Sc after fusion with R_1). Rs with only five branches, the stalks of R_{2+3} and R_{4+5} equal. M with only four branches, the stalk of M_{1+2} long, that of M_{3+4} short. Cu_1 standing well away from M_4 and very slightly concave to it. M and Cu_1 fused for a space basally. Cu_2 and 1A strongly fused together to about half-way, then diverging strongly. 2A bent and linked with 1A by a cross-vein. Distal portion of wing with weak, scattered cross-veins.

The characters which mark this wing as a hindwing are its general shape, with rather pointed apex, the form of Sc, the four-branched condition of M, the fusion of Cu_1 with M basally and the strong fusion of Cu_2 with 1A.

Type: *Holotype hindwing*, Specimen No. 107 in Mr. Mitchell's collection; found by Mr. Mitchell at Belmont in 1925. This is the finest Mecopterous wing yet discovered in the Belmont Beds.

16. PARACHORISTA BAIRDAE (Till.).

Archipanorpa (?) *bairdae* Till., These PROCEEDINGS, xlvii, 1922, p. 284, Pl. xxxiii, fig. 1.

This fragment is removed provisionally to this genus, though there is scarcely enough of it preserved to enable it to be placed with certainty. The preserved portion is 12 mm. long, indicating a complete wing of about 30 mm.

Type: *Holotype fragment*, Specimen No. P1 in Mr. Mitchell's collection.

Suborder PROTOMECOPTERA.

Family **Protomeropidae.**

This family was founded for the reception of the genus *Protomerope* Till. from the Lower Permian of Kansas, in which the costal space is broadened and carries a complete system of costal veinlets. Two new genera belonging to it occur in the Upper Permian of New South Wales, and may be distinguished as follows:

All the branches of Rs and M fork distally before reaching the wing-margin .... Genus 4. *Permomerope*, n.g.

All the branches of Rs and M run straight to the wing-margin without forking .... Genus 5. *Aphryganoneura*, n.g.

Genus 4. PERMOMEROPE, n.g. (Text-fig. 13.)

Very closely allied to *Protomerope* Till., from which it differs only in the possession of a slightly chitinized pterostigma without any veinlets and in some marked differences in the method of forking of the branches of M. (Unfortunately the basal portion of the wing is missing, so that the exact interpretation of this forking is not possible).

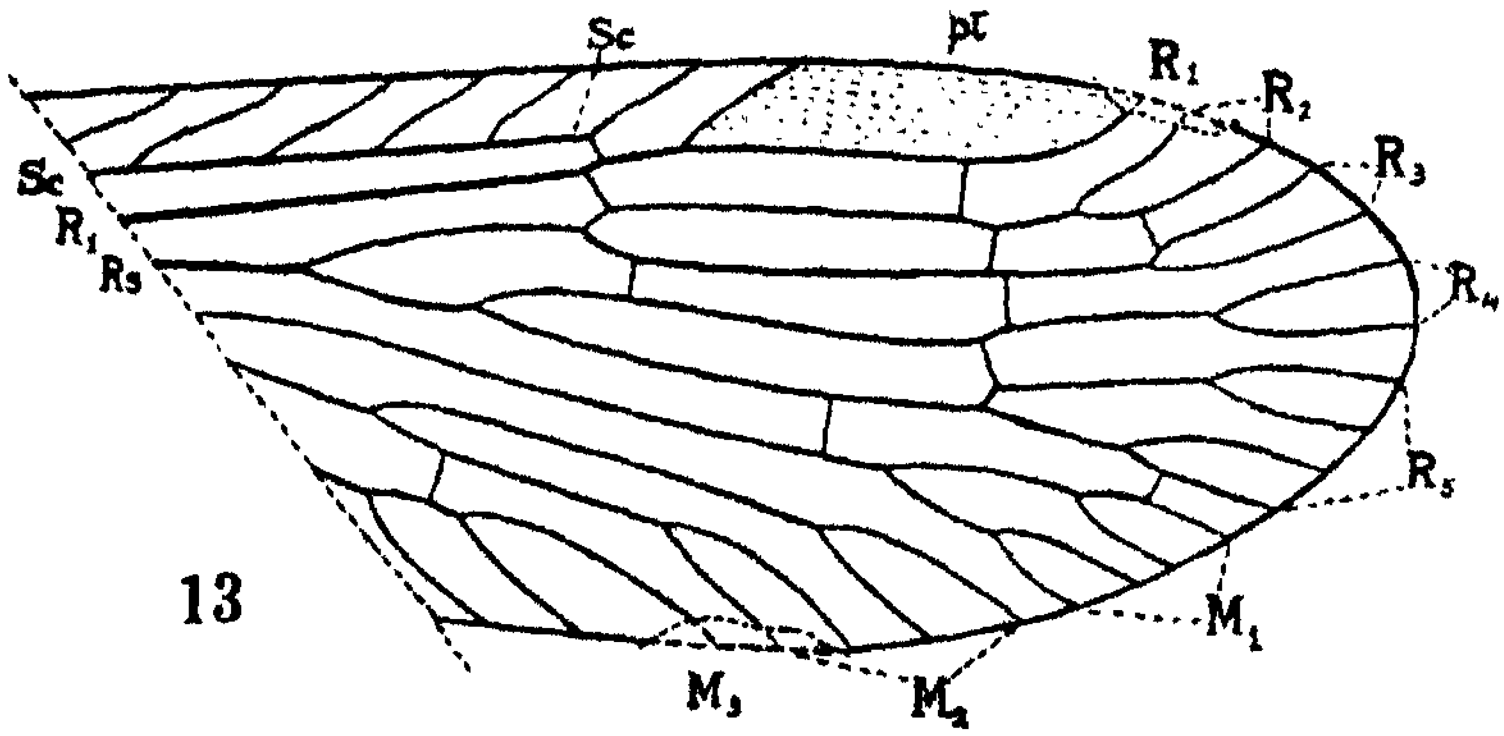
Genotype: *Permomerope australis*, n. sp.

Horizon.—Upper Permian of Belmont, N.S.W.

17. PERMOMEROPE AUSTRALIS, n. sp. (Text-fig. 13.)

This species is represented by obverse and reverse impressions of a right forewing with basal part cut off obliquely; length 9 mm., indicating a complete wing of about 12 mm. in length. The venation is rather weak and strongly suggestive of the Order Neuroptera; nevertheless, a comparison with the Lower Permian genus *Protomerope* shows that this wing is a true Mecopteron closely allied to that older genus and probably directly descended from it. The resemblance of these fossils to Raphidioidea is obvious, and there can be little doubt that this latter group evolved as a specialization for arboreal life from these more primitive forms.

In the preserved portion, Sc shows a series of five oblique and regularly arranged veinlets apart from the upturned end; it is connected distally with R_1 by a short strut. Pterostigma long, without definite veinlets but slightly chitinized. Two cross-veins distally between R_1 and R_2. Stalk of R_{2+3} longer than that of R_{4+5}. Rs has altogether ten branches, there being a single distal fork on each vein R_2, R_3 and R_4 and two distal forks on R_5. No less than eleven branches of M are



Text-fig. 13. *Permomerope australis*, n.g. et sp. Forewing. Specimen No. 100. *Length 9 mm.*

visible, but their distribution between M_1, M_2, M_3 and M_4 is only problematical owing to the absence of the basal connections; probably these eleven branches belong entirely to M_1, M_2 and M_3, while M_4 is missing from the specimen.

Type: *Holotype forewing*, Specimen No. 100 (obverse) in Mr. Mitchell's collection and counterpart (reverse) in Cawthron Institute Collection; found by Mr. Mitchell at Belmont in 1924. An impression of the body of a small beetle (Specimen No. 101) lies on the same piece of rock.

Genus 5. APHRYGANONEURA, n.g. (Plate xvi, fig. 5.)

Distinguished from all other Mecoptera by the branches of the main veins being parallel, separated by grooves as in Neuroptera Planipennia, and unbranched distally (except for a single tiny fork at end of one of the anterior branches of Rs). As far as can be seen, Cu_1 is unbranched; this and the absence of terminal branches prevents this genus from being placed within the Planipennia, though the general arrangement of the veins suggests that usually found within that group. The broadened costal space with oblique veinlets (mostly obliterated in the fossil) indicates a position within the Protomeropidae.

Genotype: *Aphryganoneura anomala*, n. sp.

Horizon.—Upper Permian of Belmont, N.S.W.

18. APHRYGANONEURA ANOMALA, n. sp. (Plate xvi, fig. 5).

A fairly complete wing, with anal area missing, and cracked across the middle; length 12 mm.; obverse impression, with apex to left, on whitish chert. It is impossible to give a drawing of this wing, as the impression is too poor to enable the connections of the branches to be properly made out. About thirteen parallel veins can be seen; of these, eight would appear to belong to R, four to M and one to Cu_1. The peculiar grooves between the veins, and the arrangement of the

weak system of cross-veins, can be seen easily from Plate xvi, fig. 5. It is to be hoped that a better preserved specimen of this extraordinary wing may one day be discovered, so that its structure may be investigated with greater certainty.

Type: *Holotype*, Specimen No. 94 in Mr. Mitchell's collection; found by him at Belmont, 20th September, 1924.

Order **Paramecoptera.**

No further specimens belonging to this Order have so far been found. The two known genera are both monotypic, and can be distinguished as follows:

Cu_1 with a small terminal fork .... Genus 1. *Belmontia* Till.
Cu_1 simple .... Genus 2. *Parabelmontia* Till.

Genus 1. Belmontia Till.

(These Proceedings, 1919, xliv, p. 234, and Pls. xii, xiii.)

Genotype: *Belmontia mitchelli* Till., *l.c.*, p. 235.

Horizon.—Upper Permian of Belmont, N.S.W.

Genus 2. Parabelmontia Till.

(These Proceedings, 1922, xlvii, p. 285, and Pl. xxxiii, fig. 2.)

Genotype: *Parabelmontia permiana* Till., *l.c.*, p. 286.

Horizon.—Upper Permian of Belmont, N.S.W.

These two genera are placed in distinct families, Belmontiidae and Parabelmontiidae, respectively. The former appears to be ancestral to the Trichoptera and Lepidoptera, the latter to the Diptera, through the Triassic Paratrichoptera or Protodiptera.

Order **Neuroptera.**

Suborder Planipennia.

Family **Permithonidae.**

For the present, all the new forms of Planipennia found in the Upper Permian of New South Wales will be retained in this family, owing to the fragmentary nature of some of the specimens. When more complete specimens are available, it will probably be found that at least two families are represented. The genera can be distinguished by the following key:

1. M forking distad from the level of the origin of R_{4+5} 2
   M forking before level of origin of Rs 3
2. Costal space with veinlets simple or once forked; cubital space (between Cu_1 and Cu_2) with a few simple cross-veins .... Genus 1. *Permithone* Till.
   Costal space with complex system of branching veinlets connected by cross-bars; cubital space reticulated .... Genus 2. *Permoraplsma*, n.g.
3. Wings of normal shape; Rs with few pectinate branches placed wide apart and with R_{4+5} forking far from its origin .... Genus 3. *Permosmylus*, n.g.
   Wings very broad; Rs with numerous pectinate branches close together and with R_{4+5} forking close to its origin .... Genus 4. *Permopsychops*, n.g.

Genus 1. Permithone Till.

(These Proceedings, xlvii, 1922, p. 289, Text-fig. 6, Pl. xxxiii, fig. 3.)

Genotype: *Permithone belmontensis* Till.

Horizon.—Upper Permian of Belmont, N.S.W.

Two species of this genus are now known, and can be separated as follows:

Costal space broadened basally, narrowed distally; pterostigma with numerous closely-set veinlets .... *P. belmontensis* Till.
Costal space of medium width throughout; pterostigma with only three or four weak veinlets further apart .... *P. oliarooides*, n. sp.

1. PERMITHONE BELMONTENSIS Till.

(These PROCEEDINGS, 1922, xlvii, p. 290.)

The costal veinlets are for the most part simple, but two or three of them are distally forked.

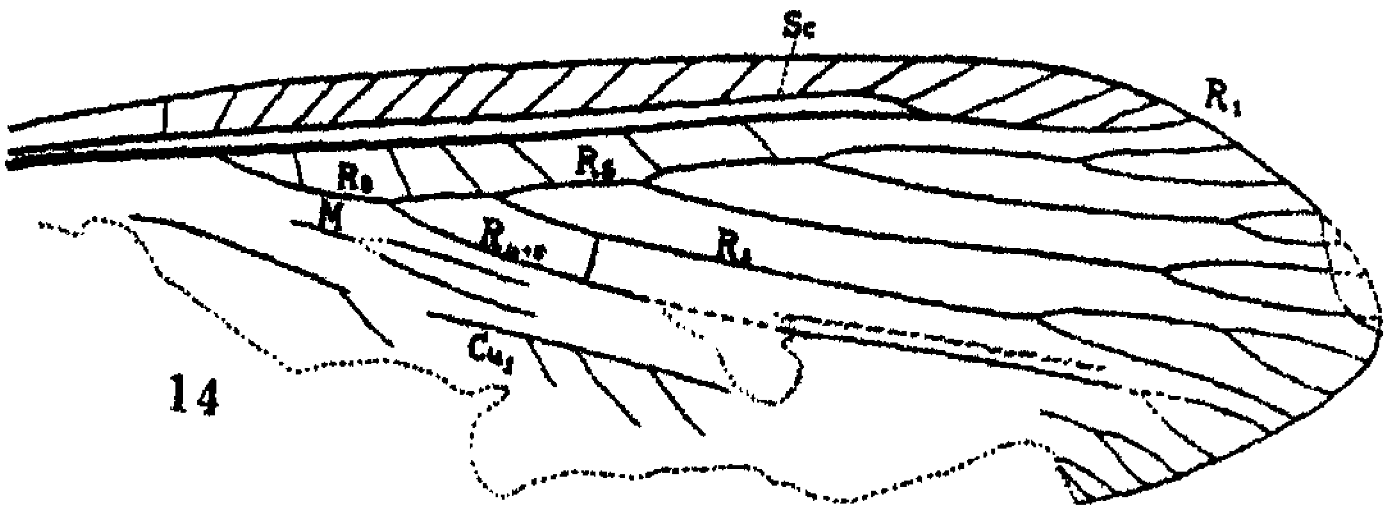
Type: *Holotype forewing*, Specimen No. 52 in Mr. Mitchell's collection. A second Specimen, No. 97, found by Mr. Mitchell at Belmont in 1924, is in the Cawthron Institute Collection; it is in a very poor state of preservation.

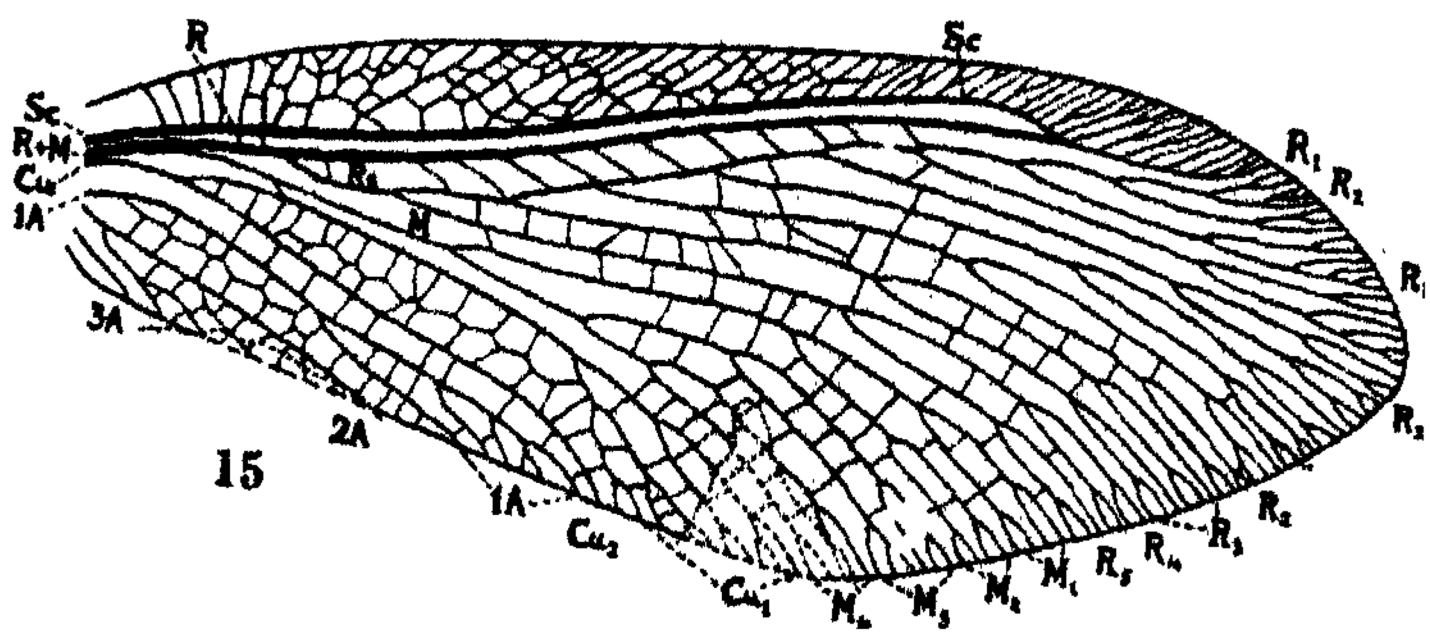
2. *PERMITHONE OLIARCOIDES*, n. sp. (Text-fig. 14.)

A rather poor reverse impression with apex to left; length 9 mm. The lower half of the wing is more or less broken away, so that only Sc, R_1 and the branches of Rs are preserved plainly. Apparently the wing crumpled up in the region of M, but a small portion of Cu_1 can be made out, with two or three descending branches of a pectinate series. Rs has a pectinate series of five branches, the most distal being very short. Six oblique cross-veins between R_1 and Rs.

Possibly this specimen may be the hindwing of *P. belmontensis* Till., but the differences appear sufficient to justify the giving of a separate name for the time being.

Type: *Holotype*, unnumbered Specimen in Mr. Mitchell's collection, labelled "Good insect wing, new, Belmont". Found by Mr. Mitchell in 1925.





Text-fig. 14. *Permithone oliarcoides*, n. sp. Length 9 mm.
Text-fig. 15. *Permorapisma biserialis*, n.g. et sp. Forewing. Specimen No. 95. Length 19 mm.

Genus 2. PERMORAPISMA, n.g. (Plate xvi, fig. 6; Text-figs. 15, 16.)

Wings of the same general type as in *Permithone*, but differing in having a much more complex venational scheme. Costal space with numerous veinlets, many of them irregularly branched and connected together by cross-bars. Sc

ending on R_1, as in *Permithone*, and arching strongly downwards before reaching R_1. Only a single cross-vein between Sc and R_1, placed close to level of origin of Rs. Between R_1 and Rs a series of fairly numerous obliquely placed cross-veins. Rs with eight or nine pectinate branches running longitudinally; the most basal of these, R_{4+5}, is forked beyond the middle of the wing. M with a fairly long, slender main stem, forking at a level distad from the origin of Rs; both branches of M with considerable further forkings distally, these forks arranged dichotomically. Cu forking close to base; Cu_1 with dichotomic distal forkings, Cu_2 simple. Cubital space (between Cu_1 and Cu_2) reticulate. 1A and 2A branched, 3A simple and very short. Terminal twiggings of all the veins from R_1 to Cu_1 very numerous. Cross-veins mostly weak and irregular, except in the spaces between Cu_1 and Cu_2 and between 1A and 2A, where they are stronger, forming a meshwork.

Genotype: *Permorapisma biserialis*, n. sp.

Horizon.—Upper Permian of Belmont and Warner's Bay, New South Wales.

The two known species may be distinguished as follows:

Forewing 19 mm. long, with a double row of cross-veins in cubital space .... *P. biserialis*, n. sp.
Much larger wing with a triple row of cross-veins in cubital space .... *P. triserialis*, n. sp.

PERMORAPISMA BISERIALIS, n. sp. (Plate xvi, fig. 6; Text-fig. 15.)

Forewing: Total length 19 mm.; greatest breadth 7 mm.

An almost perfect impression with apex to right, in colour a medium fuscous on a hard grey chert, suggesting that the wing was originally fuscous in tint. A chip in the rock has carried away a small triangular portion of the wing at the distal end of Cu_1; otherwise the wing is perfect. Of specific value are the two rows of cells between Cu_1 and Cu_2 and between 1A and 2A, the absence of cross-veins between M and Cu_1 except for a short oblique M_5 situated basally and a few weak cross-veins distally, the presence of a set of simple cross-veins between Cu_2 and 1A, and the absence of any terminal twigging to Cu_2.

Type: *Holotype forewing*, Specimen No. 95 in Mr. Mitchell's collection, undated; found at Belmont, N.S.W., by Mr. John Mitchell.

This wing seems to bear much the same relationship to the rare Indian genus *Rapisma* as *Permithone* bears to the recent Australian genus *Ithone*; this resemblance suggested the generic name given.

PERMORAPISMA TRISERIALIS, n. sp. (Text-fig. 16.)

A small fragment, 6 mm. long, of a wing of larger size than the preceding. Colouration dark fuscous on a dark grey chert. The impression is a poor one and includes portions of the two main branches of M, with the forking of M_{3+4}, and portions of Cu_1 and Cu_2 with forking of the former vein. Cu_2 has two small terminal twigs. The spaces between M_{1+2} and M_{3+4} and between the latter vein and Cu_1 have rows of simple cross-veins, while that between Cu_1 and Cu_2 has three rows of cellules. The apex of this wing was to the left.

Type: *Holotype fragment*, Specimen No. 86 in Mr. Mitchell's collection, dated 1923; found at Warner's Bay, N.S.W., by Mr. John Mitchell.

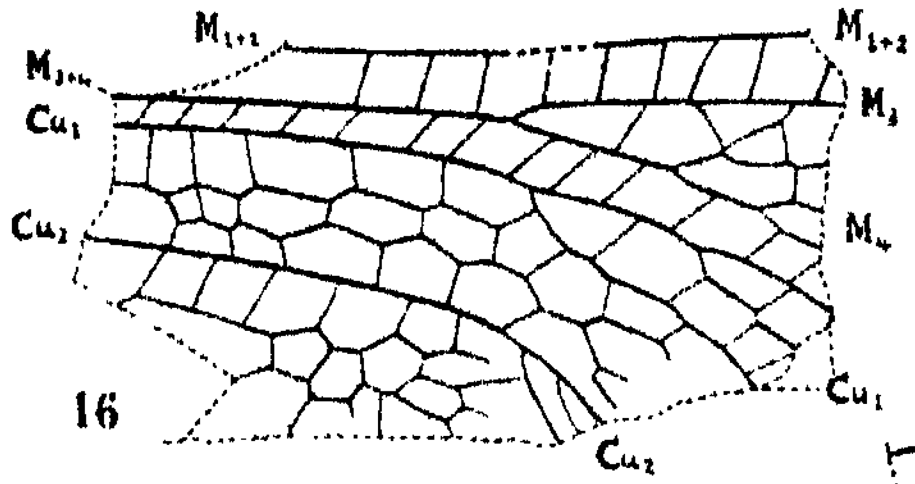
Genus 3. PERMOSMYLUS, n.g. (Text-fig. 17.)

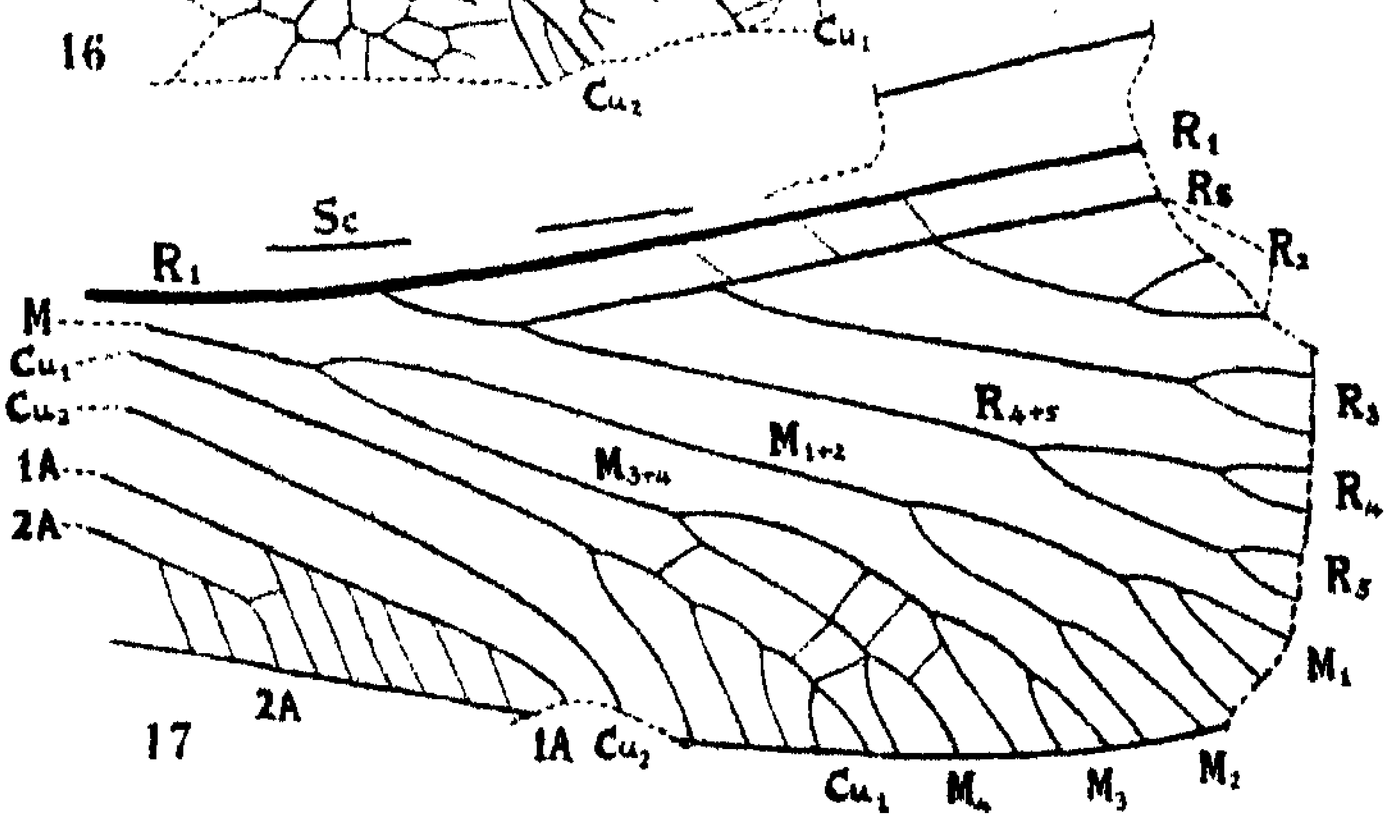
A genus of the same type as *Permithone* Till., but differing from it in having M forking at a level before the origin of Rs. Rs itself is straighter and closer to

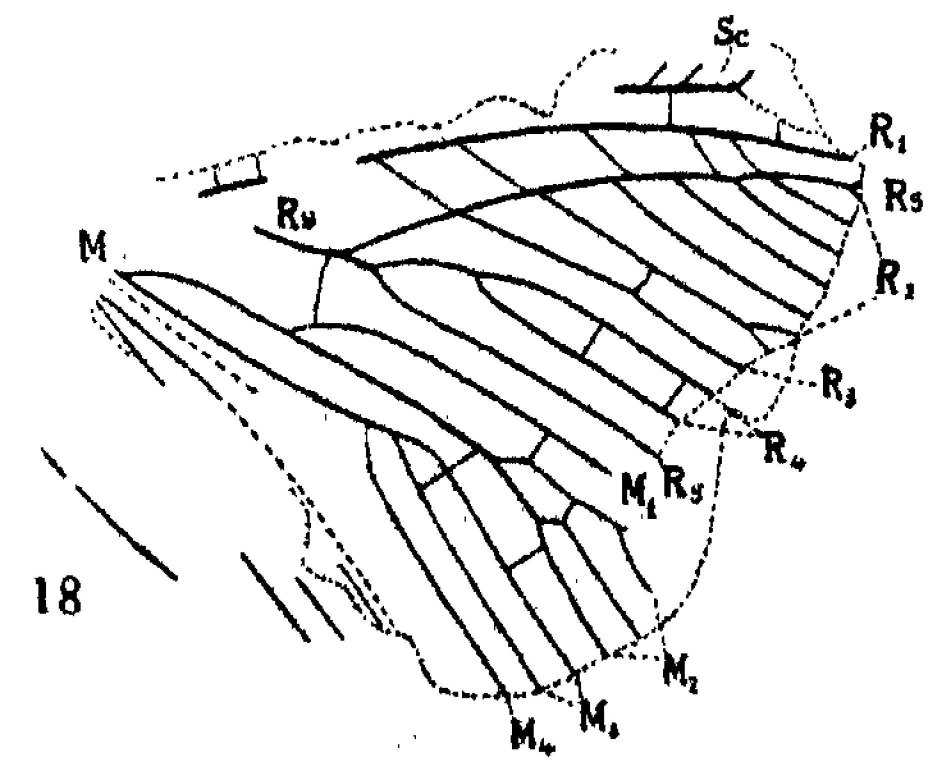
R_1 basally than in *Permithone*, but the pectinate branches are few and wide apart as in that genus, and R_{4+5} forks in the same manner. Both main branches of M are strongly forked distally, the forks being arranged dichotomically. Cu_1 has a distal pectinate series of branchlets, as have also 1A and 2A, but Cu_2 is simple. (Distal and basal parts of the wing are missing, also practically the whole of Sc.)

Genotype: *Permosmylus pincombeae*, n. sp.

Horizon.—Upper Permian of Belmont, N.S.W.







Text-fig. 16. *Permoraplsma triserialis*, n. sp. Specimen No. 36, with apex turned to right. Length 6 mm.

Text-fig. 17. *Permosmylus pincombeae*, n.g. et sp., with apex turned to right. Specimen No. P.171.

Text-fig. 18. *Permopsychops belmontensis*, n.g. et sp., with apex turned to right. Specimen No. P.156. Length 6 mm.

This genus is left provisionally in the family Ithonidae pending the discovery of a more complete specimen with the subcosta, costal veinlets and pterostigmatic region present. The forking of M close to the base recalls the recent family Osmylidae, as do also the pectinate branchings at the ends of veins 1A and 2A; hence the generic name adopted here for this genus. Only one species is known.

PERMOSMYLUS PINCOMBEAE, n. sp. (Text-fig. 17.)

A fragment 7 mm. long of a wing about 12 mm. total length. Colour pale greyish on hard chert of the same colour; impression faint. Only three of the pectinate branches of Rs are preserved and each of these is forked; probably there were only five altogether. Each main branch of M divides distally into five. Cu_1 has a pectinate series of five descending branchlets, 1A has seven and 2A three (as far as they are preserved). Cross-veins are few and very faint; three can be made out between R_1 and Rs, three between M_3 and M_4, three between M_4 and Cu_1. The impression has the apex to the left.

Type: *Holotype fragment*, Specimen P.171 in Mr. Pincombe's collection; found at Belmont, 1925, by Mrs. Pincombe, to whom the species is dedicated.

Genus 4. PERMOPSYCHOPS, n.g. (Text-fig. 18.)

This genus is proposed for the reception of a fragment of an evidently very broad wing which appears to combine the characteristics of both Permithonidae and Prohemerobiidae, but is left in the former family pending discovery of a more complete specimen. M forks basally well before the level of the origin of Rs; this latter vein is very much bent at the point of origin of R_{4+5}, which forks almost immediately; the pectinately arranged branches of Rs are numerous and close together and run obliquely downwards across the wing, not longitudinally as in *Permithone*. Oblique cross-veins are present between R_1 and Rs. M_{1+2} forks below the bend of Rs. The directions of Rs and M_{3+4} distally diverge very strongly, giving a great width of wing between these veins, as in recent Psychopsidae; this character has suggested the generic name here given.

Genotype: *Permopsychops belmontensis*, n. sp.

Horizon.—Upper Permian of Belmont, N.S.W.

PERMOPSYCHOPS BELMONTENSIS, n. sp. (Text-fig. 18.)

A fragment about 6 mm. long of a fairly large wing, probably about 15 mm. long and 9 mm. wide or more; stained ochreous on a whitish chert. Venation faint. Only parts of R_1, Rs and M are preserved, with traces of Sc and Cu; the cubito-median furrow is visible basally (shown by a dotted line in Text-fig. 18). The peculiar branchings of R_{4+5} and M are good specific characters. Cross-veins few and very faint. The impression has the apical portion to the left.

Type: *Holotype fragment*, Specimen No. P.156 in Mr. Pincombe's collection; found at Belmont by Mr. Pincombe, September, 1924.

Besides the above-described species, there are two interesting fragments of Planipennian wings which are not complete enough to merit description.

Specimen No. 87 from Mr. Pincombe's collection is an irregularly broken fragment about 12 mm. long from the middle of a rather large wing of the type of *Permopsychops*, showing a number of the pectinate branches from the radial sector and media, with weak, irregular cross-veins here and there between them.

Specimen No. 92 from Mr. Pincombe's collection is a very small fragment about 6 mm. long of what must have been a very large wing of Planipennian type. The veins are thick and about 1 mm. apart, and the separate cellules are from 1 to

1·5 mm. long. Portions of four main veins are shown, two of which arise together at a fork; eight or nine cross-veins are also visible connecting these. An estimate of the size of this wing when complete would be that it was somewhere between 40 and 50 mm. in length.

EXPLANATION OF PLATES XV-XVI.

Plate xv.

Fig. 1. *Permochorista jucunda*, n. sp. Length 7·3 mm.
Fig. 2. *Permochorista collinsi*, n. sp. Length 8·5 mm.
Fig. 3. *Parachorista pincombeae*, n.g. et sp. Length 12 mm.

Plate xvi.

Fig. 4. *Parachorista splendida*, n. sp. Length 15 mm.
Fig. 5. *Aphryganoneura anomala*, n.g. et sp. Length 12 mm.
Fig. 6. *Permorapisma biserialis*, n.g. et sp. Length 19 mm.

(All photographic enlargements by Mr. W. C. Davies, Curator of the Cawthron Institute, Nelson.)

CONTRIBUTIONS TO THE CYTOLOGY AND PHYLOGENY OF THE SIPHONACEOUS ALGAE.

Part ii. Oogenesis and Spermatogenesis in Vaucheria geminata.

By May M. Williams, M.Sc.,
Linnean Macleay Fellow of the Society in Botany.

(Sixteen Text-figures.)

[Read 30th June, 1926.]

Introduction.

In a previous paper (These Proceedings, 1, 1925) the writer described the cytological processes occurring during the development of the gametangia of *Codium tomentosum*, and from the results there described it seemed justifiable that the processes of oogenesis and spermatogenesis in *Vaucheria* might be re-investigated for any similar phenomena. Cytological details of the reproductive organs of *Vaucheria* and its position in the general classification of the Chlorophyceae have for a long time been a puzzle to cytologists. This may be accounted for to a certain extent by the extremely minute size of the nuclei, which makes their examination a rather difficult problem. However, the subject still requires investigation on account of the conflicting opinions in regard to oogenesis. Davis, in 1904, described the uninucleate oogonium of this type as being derived from a previous multinucleate condition by the disintegration of numerous supernumerary nuclei and the ultimate survival of a single nucleus to preside over the activities of the oosphere. This was undoubtedly an advance on previously recorded investigations such as those of Behrens (1890) and Oltmann (1895) who described the uninucleate as being derived from the preceding multinucleate condition in a very different manner. The former described it in terms of the fusion of the supernumerary nuclei, and the latter by the retreat of all the nuclei, except one, back into the parent filament. Klebahn (1892) maintained that the egg and oospore were multinucleate. In 1908, Heidinger made observations on numerous species of *Vaucheria* and his results were in agreement with those of Oltmann in that all the nuclei, except one, retreat from the oogonium before it is cut off by a transverse wall. This would involve a process which has not been recorded from any other type or group of the plant kingdom and would at once remove *Vaucheria* from undoubtedly related types. The results of Davis (1904) are probably more generally accepted.

According to the classification set forth in the first part of this series of papers (1925, p. 99), the Vaucheriaceae were regarded as representing the climax family of the Siphonales, and as the only types producing heterogamous gametes in an assemblage of forms characteristically isogamous. Many algal systematists, notably Blackmann and Tansley (1902) offer various objections to their position as the terminal family of the Siphonales, and place them as the end family of the Heterokontae near the Confervales, maintaining that they are not really representative of the group and have little in common with the Siphonales except in the presence of a coenocytic vegetative body, the order being better represented by such types as *Codium* and *Bryopsis*.

The Vaucheriaceae were regarded primarily as being the progenitors of the Phycomycetous Fungi, but as the result of subsequent research they may now represent a parallel line of development with such Fungi, all being derived from some less specialized type whose sexual organs consisted of isogamous gametes produced in gametangia. Davis (1904, p. 83) has remarked: "The absence of nuclear divisions in *Vaucheria* presents serious difficulties to the theories of some authors that such mitoses indicate reduction phenomena in those fungi where they have been studied". This quotation illustrates very well the opinion of cytologists who were at that time investigating these problems. With such diverse explanations of vital phenomena and the importance of *Vaucheria* in any phylogenetic speculations in this region, it seemed that the type was open to further investigation, and a study of the cytology with our improved knowledge of technique since the early part of this century might lead to helpful conclusions.

Methods

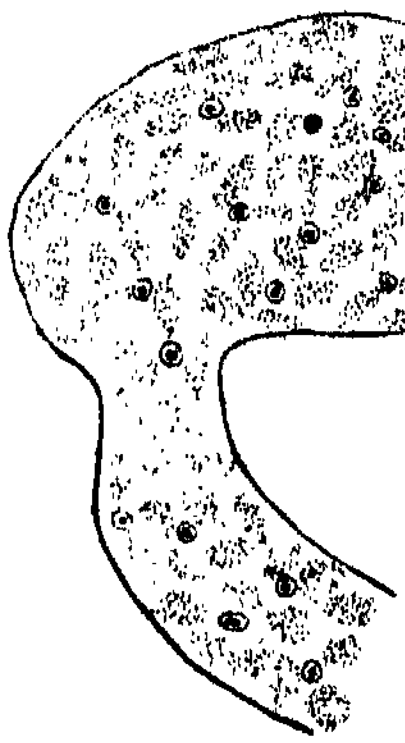
The material for the present investigation was fixed in the laboratory, under perfectly normal conditions, at intervals of an hour for a period of twenty-four consecutive hours. Fixations were made in February, March, April, June, and August. In all instances the condition of the material was particularly favourable for a study of the sexual organs. It has been a matter of common experience among algologists that in freshwater Algae, mitosis in the various parts of the body occurs most frequently during the evening. Lutman (1911, p. 409) described the early stages of chromatophore and nuclear divisions in *Closterium* as occurring more frequently early in the evening, even as early as 9 o'clock, the time of maximum division being undoubtedly dependent upon the temperature of the water, and upon the character of the preceding day, whether cloudy or bright, a factor determining the amount of starch stored. T'Serclaes (1922) mentioned that in *Cladophora* most active nuclear divisions occurred between 9 and 10 p.m.

For the present investigation, material of *Vaucheria* was fixed in Flemming's weaker and Flemming's stronger fluid diluted with equal parts of water. The fixative was allowed to act in the case of the stronger solution for twelve hours, the weaker solution for double that period. An air pump was used in order to facilitate the infiltration of the fluid. The material was then washed for twenty-four hours. With regard to the subsequent treatment, the method followed was mainly similar to that employed by Bagchee (1925, p. 222) on the young ascocarps of *Pustularia*. After washing, the material was placed in 10% glycerine, which was slowly evaporated until it became of the density of pure glycerine. The material was then taken through various grades of glycerine and absolute alcohol mixtures, then mixtures of absolute alcohol and chloroform and finally cleared in chloroform. The whole process of clearing and embedding was completed within six hours. This method gave very satisfactory results. Material was imbedded in paraffin and sections cut 3 μ to 5 μ in thickness. The staining processes most extensively employed were Haidenhain's iron-alum haematoxylin, and Flemming's triple stain. The latter process gave very good results and was used extensively during the course of the investigation, results being confirmed with Haidenhain's haematoxylin.

Throughout the course of the investigation it was found necessary to use the Zeiss apochromatic objective 1·8 mm., with compensating oculars, since the nuclei are so minute as to defy examination under lower magnifications.

Investigation.

The results of the investigation here recorded are very closely in accordance with those obtained by Davis (1904) on this type, in that the young oogonium was observed to be multinucleate, the ultimate uninucleate condition of the mature oogonium resulting from the degeneration of numerous supernumerary nuclei.



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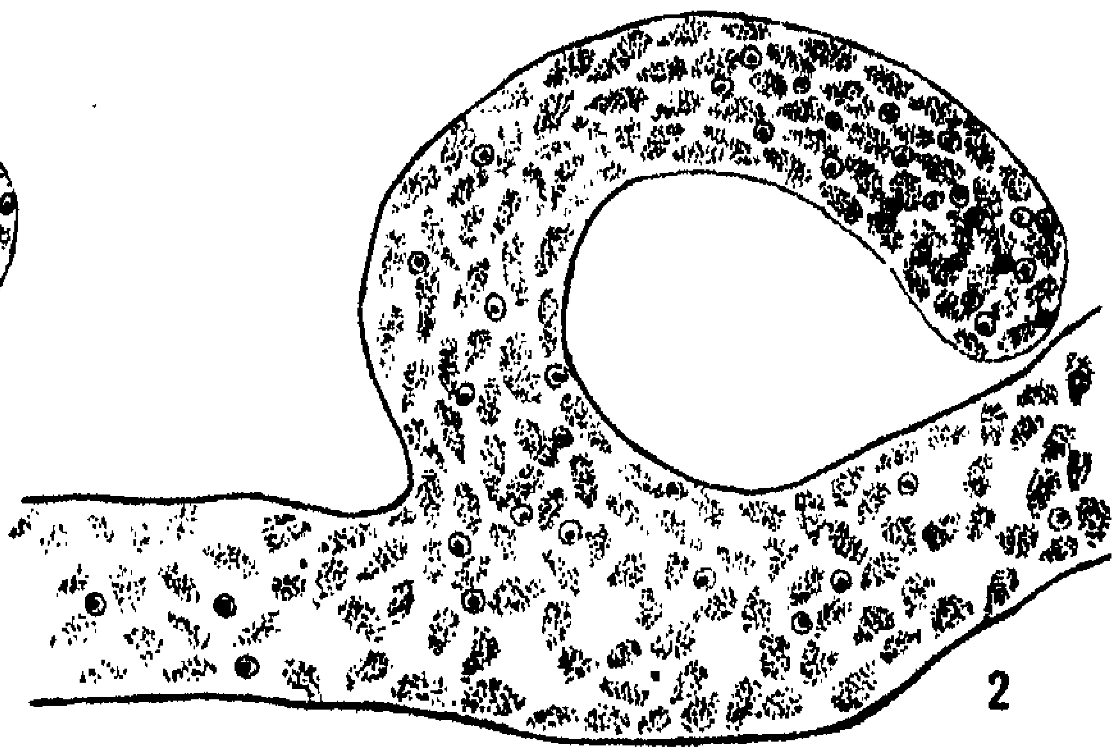

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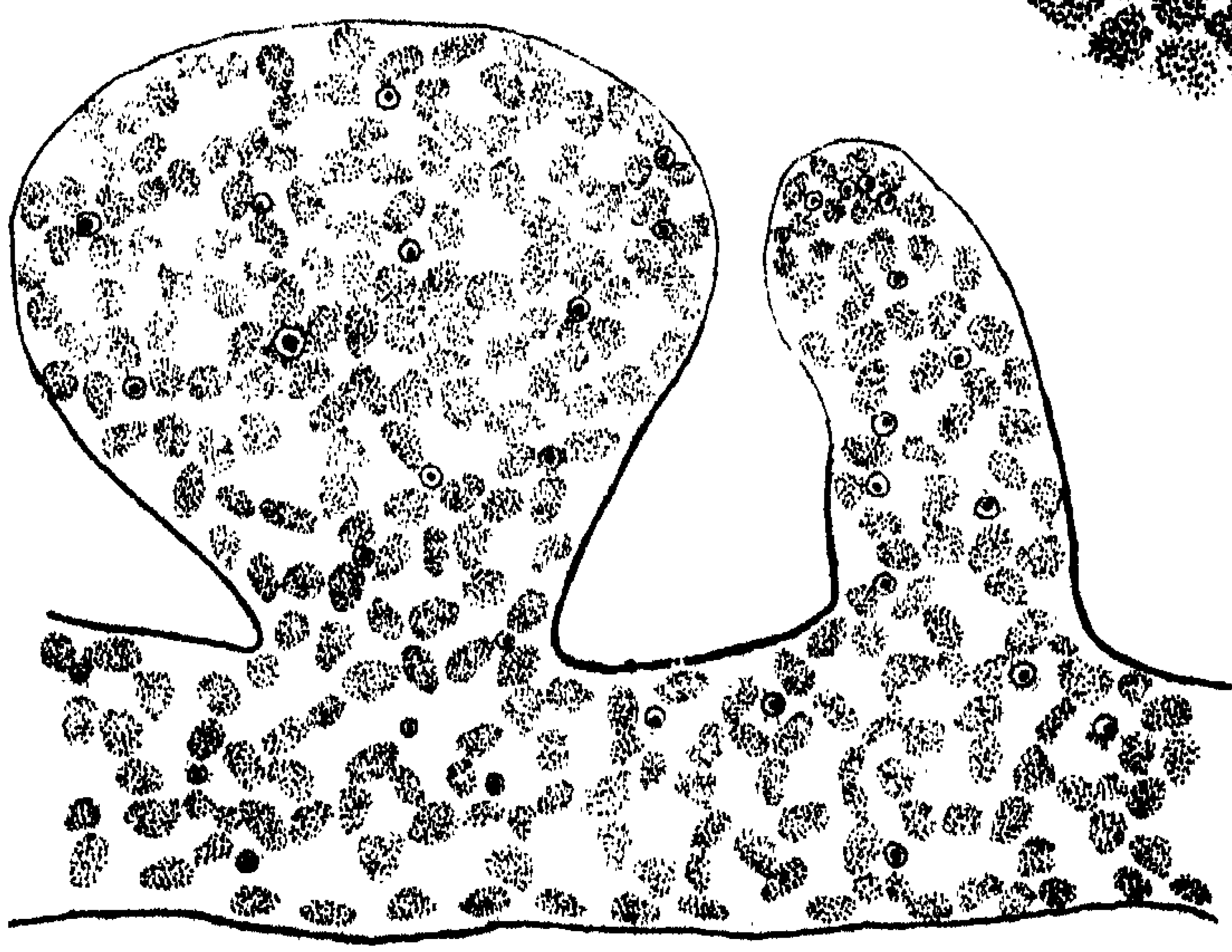

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Text-fig. 1. The young oogonium becoming evident as a slight protuberance containing numerous nuclei and not, as yet, cut off by a cell wall. × 610.

Text-fig. 2. This indicates the growth of the young antheridium showing the numerous nuclei present within it. × 610.

Text-fig. 3. The nuclei of the young oogonium showing their comparatively small size, the nuclear membrane, fairly large nucleolus and the very faint chromatin reticulum. × 2,000.

Text-fig. 4. The young oogonium and antheridium of *V. sessilis*, showing the further development just previous to the formation of the cross partition. One of the nuclei has already commenced to enlarge. × 610.

Moreover, the writer was unable to observe mitosis at any stage in the development of the oogonium or antheridium, although a careful search was made for it. Mitotic figures were frequently observed in the coenocytic vegetative filaments, in material fixed at various periods during the evening, but the nuclei of the sexual organs invariably showed those characters associated with the so-called "resting period" or non-mitotic state.

The sequence of events occurring during the oogenesis and spermatogenesis in *Vaucheria* as observed by the writer are as follows. The young oogonium and antheridium first become evident as a small protuberance into which flows a definite quantity of protoplasm and protoplasmic contents (Text-figs. 1 and 2). Further increase in the size of these protuberances is brought about by an increased quantity of protoplasm flowing in from the vegetative filament and a stretching of the wall of the young sexual organs in order to accommodate this added bulk. This stretching of the wall is readily observed, as the wall at the apex of the oogonium is always thin, whereas at the base it is comparatively thick (Text-figs. 1, 2 and 4). The protoplasm of the oogonium and antheridium at this period of their early development is fairly dense and the vacuoles are comparatively minute. The nuclei are usually aggregated at the apex, uniform in size, of approximately the same dimensions as those occurring in the filament, and usually smaller than the plastids. The number of nuclei carried into the young oogonium, by actual count in consecutive sections, was seldom found to exceed 30. The nuclei at this period consist of a thin nuclear membrane, a comparatively large nucleolus and a faint chromatin reticulum (Text-fig. 3). The nuclei become more evenly distributed through the oogonium: the protoplasm is less dense and assumes a more or less alveolar appearance, large vacuoles appearing with it. When development has proceeded thus far, i.e. when the oogonium has attained about two-thirds of its mature size, a transverse septum is formed which separates the oogonium from the parent filament. The protoplasm now begins to rearrange itself so that it comes to lie in a small central area with a layer of protoplasm lining the wall of the oogonium, the vacuoles being traversed by delicate threads which connect the widely separated regions (Text-fig. 5).

It is this period of development to which the author has devoted much time

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Text-fig. 5. *This indicates the development of the oogonium just after the formation of* the cross partition. The protoplasm has come to lie in a small central area with a portion lining the wall. The large vacuoles are traversed by delicate threads. The nucleus in the central region is rapidly increasing in size while the other nuclei are degenerating. × 610.

Text-fig. 6*a*. This indicates the degeneration of a few nuclei within the oogonium. The reticulum and membrane have almost disappeared. × 2,000.

Text-fig. 6*b*. The nucleus of the central region of the oogonium indicating a considerable increase in the size of the nucleus and in the chromatin content. × 2,000.

Text-fig. 7. This indicates the further development of the oogonium after the formation of the cross partition. In this instance, the functional nucleus is near the oogonial wall, in proximity to the pore through which the sperm will enter. The other nuclei are undergoing degeneration. × 610.

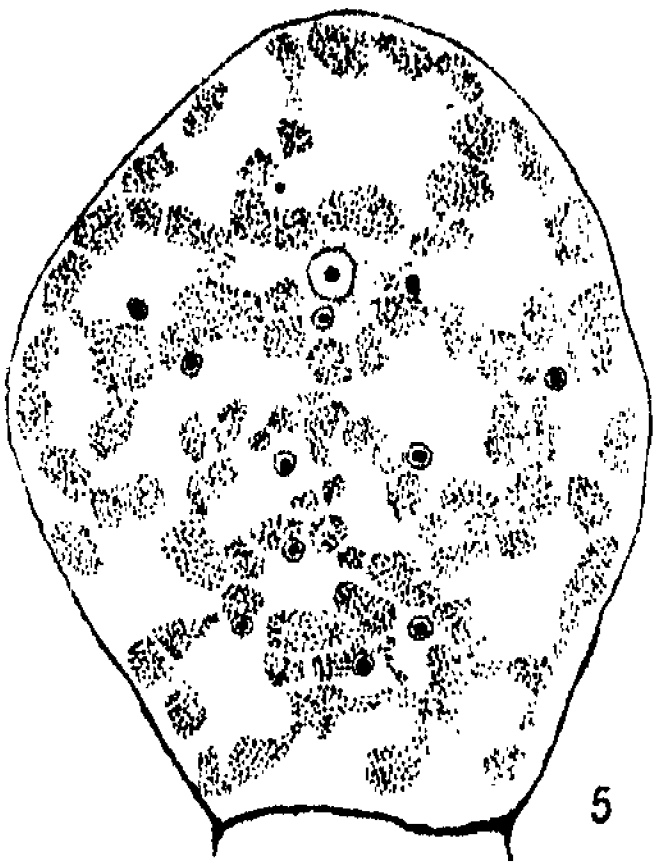
Text-fig. 8. This indicates an oosphere ready for fertilization. There is a single large functional nucleus present. × 610.

Text-fig. 9. The single functional nucleus of the oosphere. It has a thin nuclear membrane and a relatively abundant chromatin reticulum. × 2,000.

Text-fig. 10. This indicates an oosphere in which the sperm nucleus is approaching the egg nucleus. It is to be noted that the sperm nucleus is very large and almost equal in size to the egg nucleus. This condition might be mistaken for a binucleate oosphere, but the relatively thick wall indicates that the condition has arisen after fertilization. × 610.

and attention in a search for nuclear divisions, since it is at this period just after the formation of the transverse septum and prior to nuclear degeneration that the mitoses occurring in *Albugo* and *Saprolegnia* have been described. However, such phenomena were found to be absent and the writer feels convinced that they do not occur.

From this period onward, extensive nuclear degeneration is to be observed, such degeneration being entirely absent from the life-history previous to the



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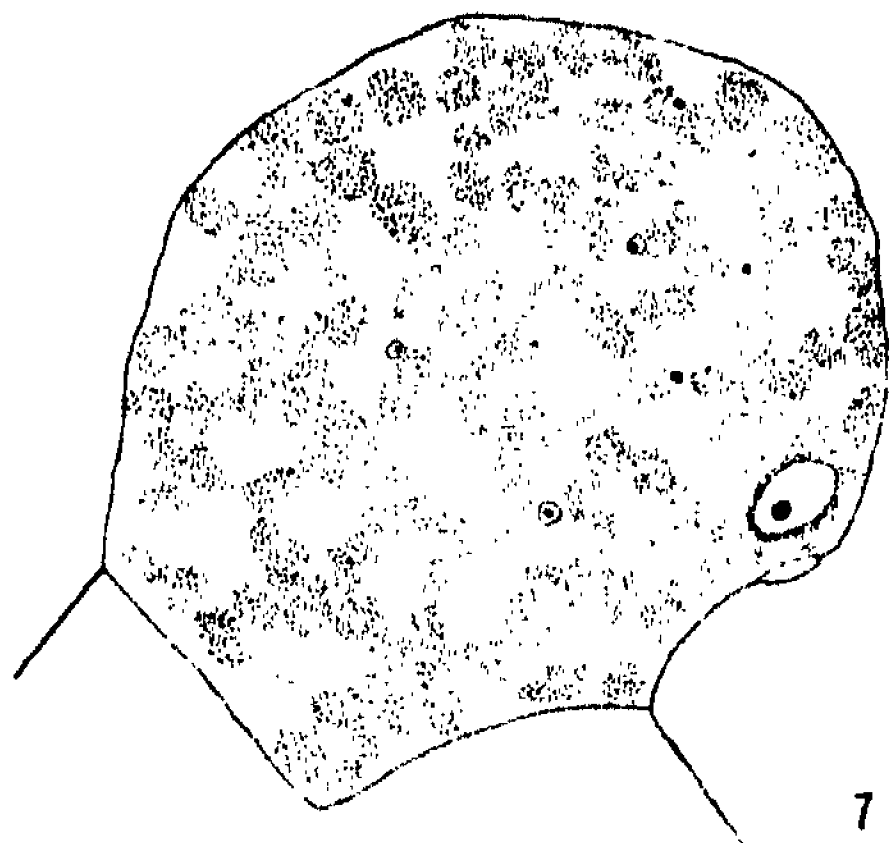

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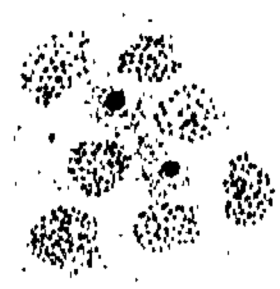
6 *b*



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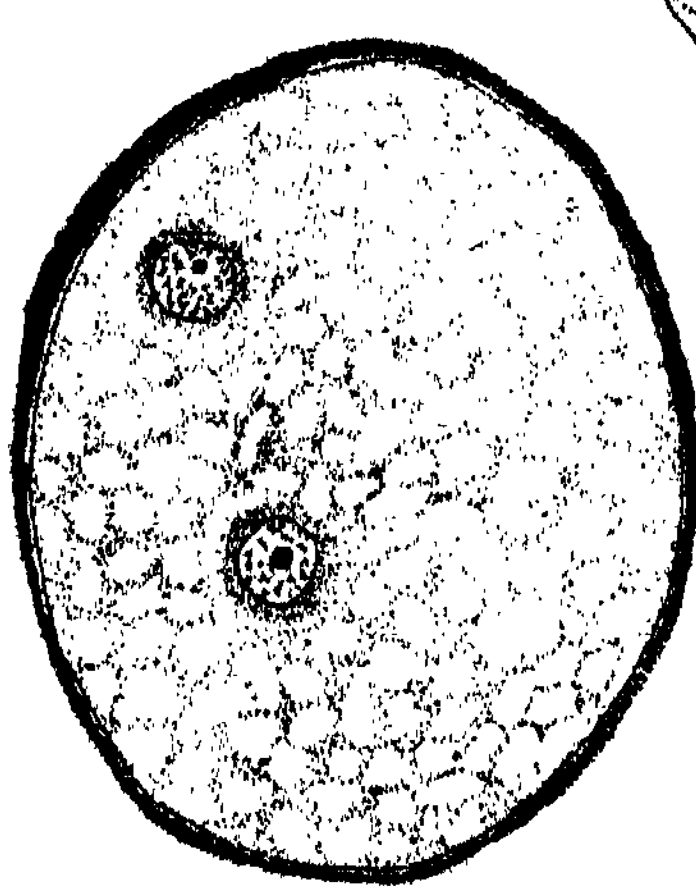

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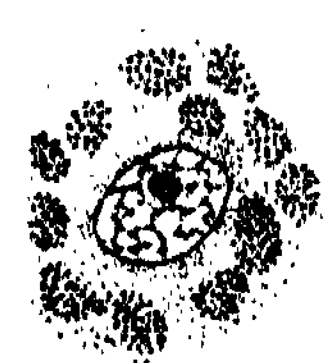

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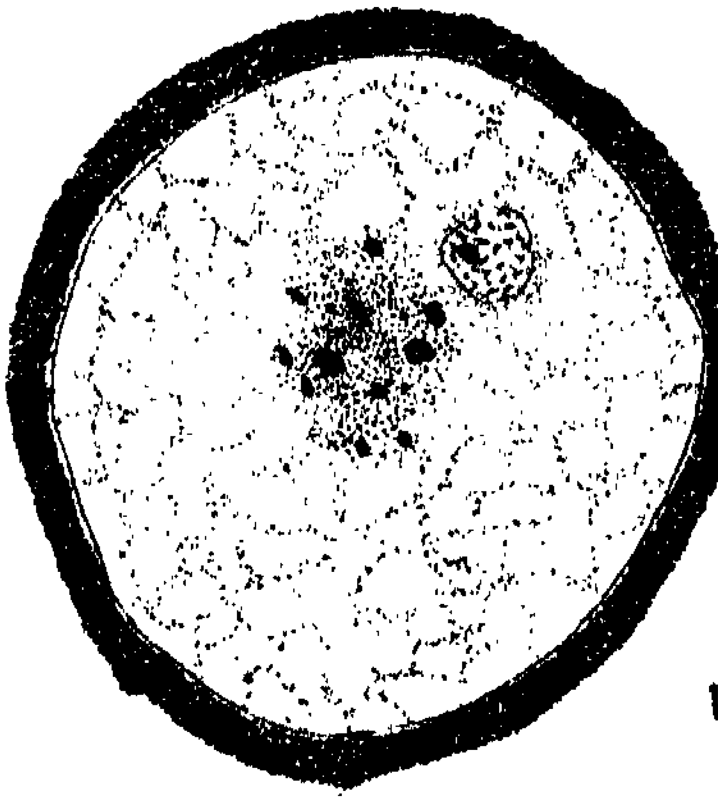
formation of the transverse septum. Davis (1904, p. 84) has described the nuclear degeneration as having its inception just previous to the formation of the cross-partition. This nuclear degeneration commences with the disappearance of the faint chromatin reticulum followed by the loss of the nuclear membrane, until finally all that can be observed is the nucleolus denoting the former existence of the nucleus (Text-fig. 6*a*). The degeneration of the nucleolus is evidently extended over a fairly long period judging by the relatively common occurrence of this stage in the preparations examined.

Coordinate with this nuclear degeneration, there is to be observed in the central mass of protoplasm a nucleus which increases very rapidly in size, at the same time showing considerable increase in chromatin content, the nucleolus not exhibiting any variation in size (Text-figs. 5 and 6*b*). This is the nucleus which will survive as the functional egg-nucleus controlling the activities of the egg or oosphere (Text-fig. 8). Text-fig. 7 indicates an oogonium in which the egg-nucleus is developing in proximity to the pore through which the sperm will enter. It is interesting to note that at this period the surviving nucleus often exhibits a different stain reaction from the supernumerary, thus indicating some change in its constitution. The latter absorb the gentian violet of Flemming's triple stain fairly well, while the former absorbs more safranin.

The factors responsible for the selection of the functional nucleus will be very difficult to determine. The writer was not able to observe any bodies of the nature of those described in *Codium tomentosum* (Williams, 1925) or of the nature of the coenocentra of *Saprolegnia* (Davis, 1903) or *Albugo* (Stevens, 1899, 1901). So far as observations went, no difference could be discerned in the structure or nature of that region in which the functional nucleus lies and the remainder of the protoplasm within the oogonium, except for the presence of a narrow band of more granular material around the surviving nucleus (Text-figs. 5, 7 and 8). Davis (1904, p. 86) has suggested that this central region of protoplasm in which the surviving nucleus lies is the region of the cell most favourable for nuclear growth and activity and as such is a dynamic centre. In this condition he has seen a close resemblance to certain of the Peronosporales, for example, *Pythium*, whose oogonia have merely an accumulation of dense protoplasm in place of the usual well-defined coenocentra. Exactly how far this suggestion may be taken as correct is difficult to determine, but the idea is very suggestive, since it is usually only in the central region of protoplasm that the surviving nucleus lies. Sections stained with Sudan G show no trace of oil or protein matter.

The development of the antheridium follows very closely that of the oogonium up to the point of the formation of the transverse septum. From this period onward, conditions are somewhat different. There is no rearrangement of the protoplasm into central and peripheral regions. Instead, the protoplasm seems to aggregate in the central region and here the antherozoids are formed. Oltmann (1895) has described the antherozoids as being very minute and as possessing two cilia which are far apart and point in opposite directions. The antherozoids are liberated at maturity; a pore is formed at the apex of the oogonium (Text-fig. 7) and through this opening the sperm enters. The nucleus of the sperm passes through the cytoplasm of the oosphere (Text-fig. 10), until it reaches the nucleus of the latter (Text-figs. 11, 12) when fusion takes place. Davis (1904, p. 87) has described the sperm nucleus as considerably increasing in size during its passage through the cytoplasm of the oosphere, and the writer was able to confirm this observation (Text-figs. 10, 11). Quite often there were to be observed oospheres in which two nuclei of apparently equal size were present,



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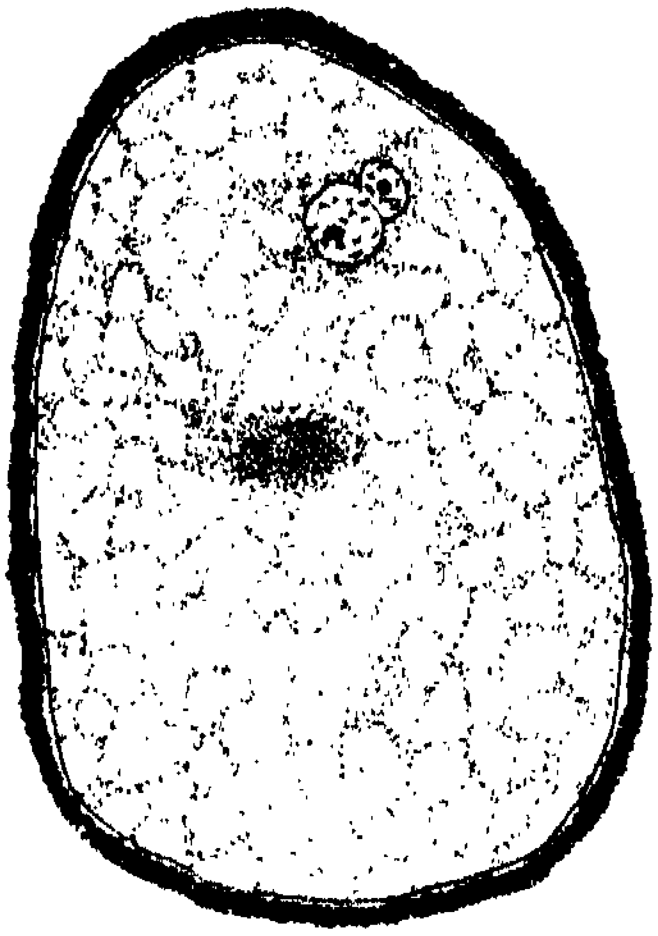

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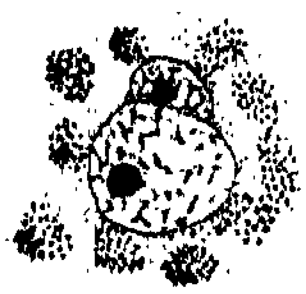

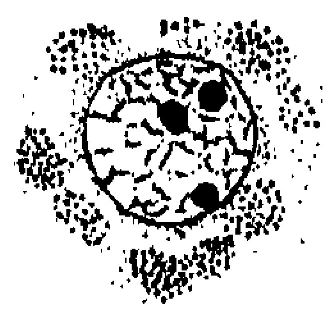

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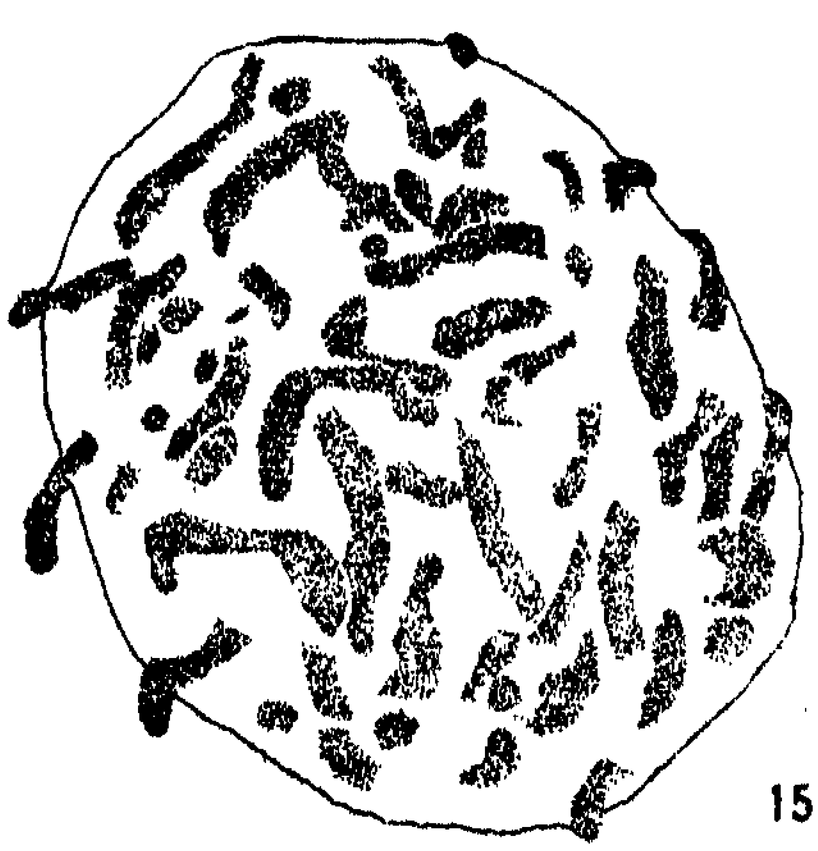

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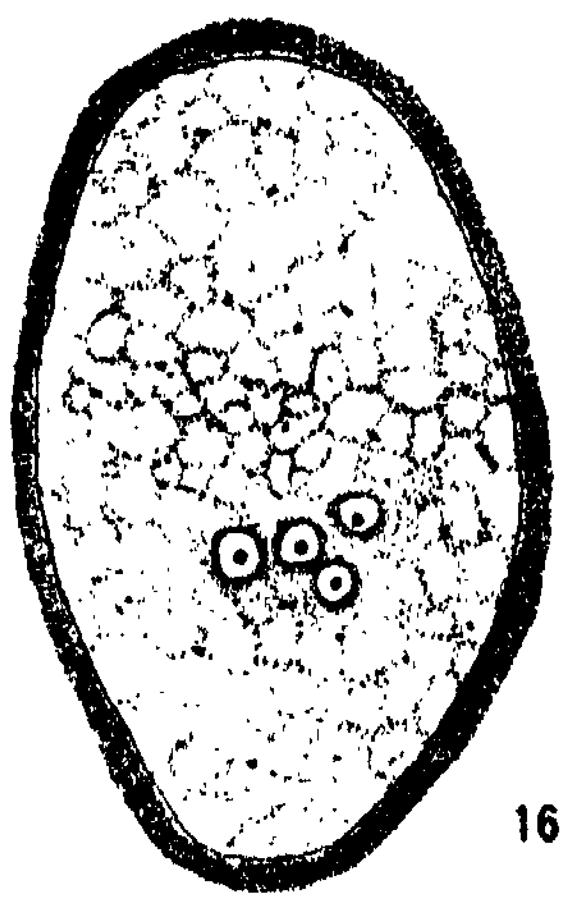

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Text-fig. 11. This indicates an oosphere in which fusion of the egg and sperm nuclei is taking place. × 610.

Text-fig. 12. The nuclei of the above. × 2,000.

Text-fig. 13. This indicates the section of an oospore showing the thick outer wall, the thin membranous inner wall, the fusion nucleus and the central mass of food substance. × 610.

Text-fig. 14. The large fusion nucleus of the oospore showing the thin nuclear membrane, three nucleoli and abundant chromatin. × 2,000.

Text-fig. 15. This indicates a surface section of the spiny outer wall of the oospore. × 610.

Text-fig. 16. This indicates the germination of the oospore. The single nucleus has undergone two mitoses resulting in the presence of four nuclei. No germ tube has yet been produced. × 610.

suggesting a binucleate egg, but on critical examination one of these could be traced back to the sperm nucleus (Text-fig. 10). The thickness of the outer wall indicates that fertilization has taken place.

On fertilization, the oospore surrounds itself with a thick wall which is often covered with spines (Text-fig. 15). The wall consists of two layers, the outer thick and the inner thin and membranous. The nucleus of the oospore is very large compared with the size of those present in the other phases of the life-history. It consists of a thin nuclear membrane, an abundant chromatin reticulum and one or more nucleoli (Text-fig. 14). The writer was seldom able to observe the nucleus of the oospore in the centre of that body as is indicated by Davis (1904, Fig. 12) excepting just immediately following fertilization. Usually it is very much to one side and the centre is occupied by a mass of very dense granular substance, the remainder of the oospore being filled with very much vacuolated cytoplasm (Text-fig. 13). This granular substance absorbs the stain with avidity; it is probably mainly nutritive in nature and drawn osmotically from the coenocyte during development, as the presence of a cell wall would not prohibit the entrance of food substances into the oogonium. The young oogonium is green in colour, i.e. it has chloroplasts within it and probably has the power of manufacturing food for itself. After fertilization, the oospore loses its chlorophyll and becomes yellow in colour.

The oospore appears to remain attached to the coenocyte for quite a considerable period after fertilization. Text-fig. 16 illustrates a stage in the germination of the oospore. It will be noted that the nucleus has undergone two mitoses resulting in the presence of four nuclei; there is no rupture in the wall of the oospore nor is any germ tube produced.

Theoretical Considerations.

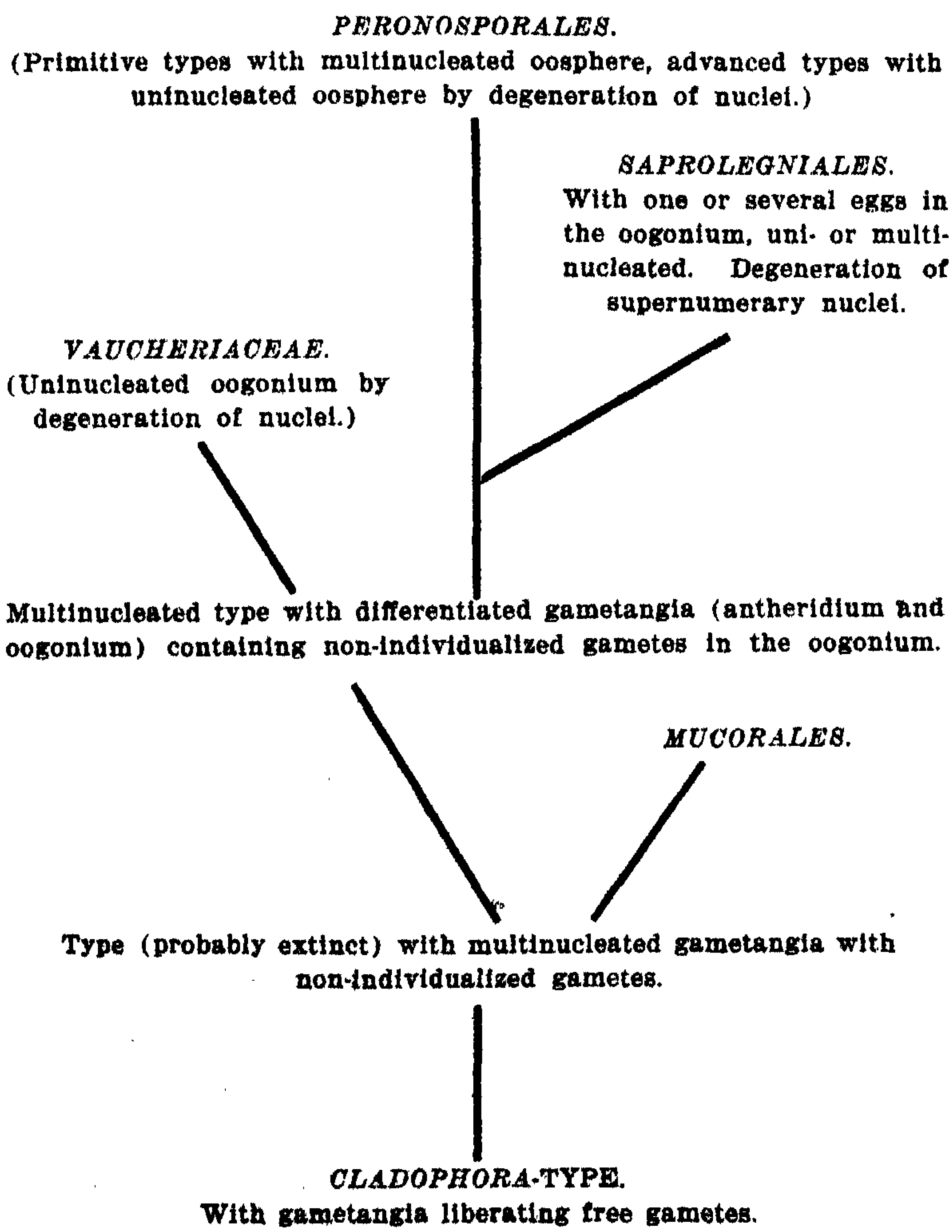
The phylogenetic interest which has become centred around the processes of oogenesis and spermatogenesis of *Vaucheria* is due to the fact that this Alga has frequently been cited as indicating conditions which apparently relate it to the Phycomycetous Fungi (*Saprolegnia*, *Albugo*, *Peronospora*, etc.). Indeed, certain earlier investigators saw in *Vaucheria* conditions which led them to derive such Fungi directly from this type. Later investigators (Stevens, 1899, 1901, and Davis, 1900, 1903, 1904) have somewhat modified this interpretation and consider all these types to have sprung from a common ancestral stock and along parallel lines of development. These writers agree that the supernumerary oospheric nuclei of these types represent gameto-nuclei; that the potential and functional gameto-nuclei are homologous; and that the oogonia of these forms are related as gametangia through some remote ancestor with incompletely differentiated oogonia.

There can be little doubt that a relationship exists between these groups when the essential processes occurring in the development of their sexual organs is taken into consideration. Davis (1904, p. 88) has pointed out that in each instance the young sexual organs are cut off from the parent filament while they are still multinucleate, and this is followed by extensive nuclear degeneration, giving rise, in its ultimate expression, to a uninucleate oogonium producing a single egg.

Davis (1904) has set forth the probable relationship of these types, and the possible homologues of their sexual organs and gametes. He has also indicated (1903, p. 248, 1904, p. 94) the possibility of these types being derived from types such as *Cladophora* or *Codium*, i.e. types with gametangia producing numerous

isogametes. Recent investigations on *Codium tomentosum* (Williams, 1925) have shown that the main processes occurring in that type are of the general nature demanded of the progenitor, except that one of the two mitoses which occur during gametogenesis is of the nature of a *reduction division*. There can be little doubt of the origin of these higher types from forms with isogametes produced in gametangia, as is typically represented at the present day by *Cladophora*, a condition which is also found in this region in many other genera of the Chlorophyceae, for example, *Bryopsis*. *Cladophora* differs from these types in possessing a septate coenocytic body, but the gametangia are truly representative of conditions required of a primitive type of sexual reproduction. For these reasons, the ancestral stock from which these Fungi have sprung might be expressed as being of the *Cladophora* type.

A table of the probable phylogenetic relationships as they appear to the writer is as follows:



This scheme takes as its foundation a type with very primitive sexual organs, which are but little removed from the asexual zoosporangium from which they are supposed to be derived. The nuclei present in the gametangia probably underwent mitosis, thus increasing the number of potential gametes. The Mucorales are indicated as branching off from a type with multinucleated gametangia and producing non-individualized gametes, retaining this character as a constant feature and so becoming an end line of development. The writer feels justified in the inclusion of this group in this general phylogenetic scheme on account of the coenocytic nature of the vegetative body, and also in view of the fact that the sexual organs of this group are undoubtedly representative of the primitive coenocyte, a structure which has undergone further elaboration in the Saprolegniales and Peronosporales. The line of evolution which has given rise to these latter groups comes off from a type with multinucleated but differentiated gametangia, i.e. the sexual organs are of the nature of oogonia and antheridia. This line has maintained the mitosis connected with oogenesis, and it is characterized by a progression towards a very specialized oogonium which in the ultimate expression is uninucleate. The extreme specialization is indicated by such characters as zonation resulting in the presence of two very distinct regions within the oogonium—the periplasm and the ooplasm of *Albugo blitii* (Stevens, 1899)—and the development of the highly specialized region within the ooplasm—the coenocentrum—best illustrated in *Albugo candida* (Davis, 1900; Stevens, 1901) and *A. lepigoni* (Ruhland, 1902). It is rather remarkable that a type such as *Albugo*, which has developed many highly specialized processes in the development of the oogonium, should have retained the primitive condition—for so it is interpreted in these types—of the occurrence of two mitoses in the development of the sexual organs. It is reasonably certain that in the Fungi with specialized nutrition, there has come a modification of the sexual processes. This is very well illustrated in the Uredinales and in various saprophytic genera of the Pezizinales, etc.

The Saprolegniales are represented as primarily developing along the same line as the Peronosporales, but diverging along an independent line before the high state of specialization has been attained. This position seems to be fairly logical for various reasons. In the first instance, both groups have varying numbers of potentially functional gameto-nuclei, and degeneration of the non-functional nuclei takes place. Secondly, *Saprolegnia* possesses what appears to be a primitive type of coenocentrum. Finally, fertilization is very much the same in the two groups. Divergence from the common ancestry is indicated by the presence of only a single mitosis during the development of the oogonium, and also by the fact that several independent eggs are developed in the oogonium at maturity. Moreover, the numerous eggs in the oogonium of many of the Saprolegniales may be interpreted as a retention of the primitive state with partly individualized gametes. On this ground the group diverges early from the stock which ultimately produces the Peronosporales. Of interest in this type are the bi- and tri-nucleate eggs described by Humphrey (1892), Hartog (1896, 1899), Trow (1895) and Davis (1903).

The male gametangium or antheridium retains its primitive state with free liberated gametes in the Vaucheriaceae and Saprolegniales because of aquatic conditions of development.

The Vaucheriaceae are represented as developing along the line from the multinucleated to the uninucleated condition by the process of degeneration of the supernumerary nuclei, at the same time eliminating mitosis from the develop-

ment of the sexual organs, these being in their ultimate expression highly specialized and heterogamous. The conditions present in *Vaucheria* appear to the writer to represent an end line of development rather than the starting point of other forms. The sexual organs of *Vaucheria* are themselves too highly specialized to have given rise to other types. With regard to the elimination of mitosis from the development of the sexual organs, it would seem that the uninucleate condition of the oogonium might be derived in a variety of ways; hence the elimination of this feature from the reproductive cycle of the Vaucheriaceae while it is retained in the Peronosporales.

It is very probable that in plants there is no distinction between body and germ plasma. Weissmann (1895) has put forward the hypothesis which postulates that all the nuclei present in the plant body have in their constitution chromosomes which carry through the plant the characters of sex. Applying this hypothesis to the case of *Vaucheria*, it would more or less explain the processes occurring in this type. Apparently, nuclei of all ages enter the young oogonia and antheridia from the vegetative body, and without any visible change, these nuclei take on sexual functions, possibly due to the fact that all the nuclei have in their constitution the characters of sex. Of course, the difficulty of this explanation is that it can rest upon no visible demonstration.

Davis (1904, p. 90) has endeavoured to trace the probable evolution of the uninucleate egg of *Vaucheria* from conditions represented in the other members of the Siphonales. He has described sexual organs of the nature of those occurring in *Bryopsis* as being a link in the series, but has left a wide gap to be filled between the sexual organs of *Bryopsis* and those of *Vaucheria*. The writer considers that this would probably involve, in the first place, a loss of motility of the female gametes, followed by a loss of individuality of the same. This would involve the fertilization of functional gamete nuclei rather than individualized gametes, these nuclei being associated together in a common protoplasmic medium. This structure would be of the nature of a primitive coenogamete. This might be followed by a type such as *Vaucheria*, where nuclear degeneration is responsible for a single uninucleate egg. This derivation is, of course, purely hypothetical, and connecting links among the Algae are unknown at the present time, but further research in this field may reveal types of this nature.

With regard to the problem of alternation of generations as illustrated by this type, it would seem probable that reduction in the number of chromosomes takes place at the first division of the nucleus of the oospore. The writer has previously described (1925) the nature of the processes occurring during the development of the gametangia of *Codium tomentosum*, and has recorded reduction in the number of chromosomes in the gametangia as the result of one of two mitoses which occur just previous to the formation of gametes. Recently Tuttle (1924) has investigated the reproductive cycle of the Characeae, and has found that in *Nitella* reduction takes place in the oogonium and antheridium—in the apical cell at an early stage in the primordium of each organ. This discovery is of particular interest since the sexual organs of the Characeae are considered to be the most highly specialized of any among the Chlorophyceae. As far as research has advanced in this field at the present time, it appears that these types are quite exceptional among the Chlorophyceae where reduction in the number of chromosomes, essential after every act of fertilization, seems to take place during the first division of the zygote or oospore. It has been definitely established as occurring at this point in *Spirogyra* (Karsten, 1908) and *Colechaete* (Allen, 1905).

Such diverse stages of the life-history at which reduction may occur within the one group, immediately raise the question as to which is the more primitive type, the occurrence of reduction during the first division of the zygote, or just previous to the formation of gametes? This is, without doubt, a very interesting question, but one which appears to lack demonstration. If alternation of generations be regarded as having had its inception in these primitive types of plant life with the periodic reduction in the number of chromosomes, it would seem that this phenomenon, like many others in the plant kingdom, has been polyphyletic in origin. The fact that reduction in the number of chromosomes may take place at such varied phases of the life-cycle in forms which are undoubtedly primitive, makes it impossible to postulate that reduction of the zygotic type is represented in the plant kingdom before any other, or vice-versa.

There can be little doubt of the importance of investigation in this region of the plant kingdom for the solution of many problems which puzzle investigators at the present day.

In conclusion, the writer wishes to express her thanks to Dr. McLuckie for interest displayed and valuable help given; also to Mr. Pritchard Smith, of the Federal Nursery, Marrickville, for supplying the material on which the investigation was made.

Summary.

1. The young oogonia and antheridia are multinucleate, the ultimate uninucleate condition of the oogonium resulting from the degeneration of supernumerary nuclei.

2. No mitoses occur during the development of the sexual organs.

3. The factors responsible for the selection of the functional nucleus are difficult to determine. No coenocentrum nor any oil or protein which might nourish the nucleus is present in this region.

4. The centre of the fertilized oogonium or oospore is occupied by a mass of very dense, granular substance. This is probably mainly nutritive in nature and drawn osmotically from the coenocyte.

5. The supernumerary oospheric nuclei represent potential gameto-nuclei; potential and functional gameto-nuclei are homologous.

6. The Vaucheriaceae are regarded as being derived primarily from a *Cladophora*-type with gametangia liberating free gametes, through types, probably extinct, with multinucleate gametangia with non-individualized gametes, these giving rise to multinucleate types with differentiated gametangia containing non-individualized gametes in the oogonium.

7. The Vaucheriaceae probably represent an end line of development since they are too highly specialized to have given rise to any other types.

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ON A SMALL COLLECTION OF PLANTS FROM THE RIGO DISTRICT, PAPUA (BRITISH NEW GUINEA).

By C. T. WHITE, F.L.S.,
Government Botanist of Queensland.

(Plate xvii.)

[Read 28th July, 1926.]

During the past year I received two small packages of plants from Papua, collected in the Rigo district by the Rev. R. Lister Turner. Most of the species received were already recorded for Papua, three proved new to science; one of these, an orchid, has already been described by Dr. R. S. Rogers as *Habenaria Turneri* (*Trans. Roy. Soc. S. Aus.*, xlix, 1925, 254), the other two are described in the present paper. In addition to the new species several others proved new records for the Territory and these are listed herewith.

Rhamnaceae.

Zizyphus Oenophila Mill., not previously recorded from the Territory.

Celastraceae.

Gymnosporia montana W. and A. Not previously recorded from the Territory.

Leguminosae.

Desmodium latifolium DC. Not previously recorded from the Territory.
Flemingia parviflora Benth. Not previously recorded from the Territory.

Rubiaceae.

PLECTRONIA SUBORBICULARIS, n. sp. (Plate xvii.)

Arbor (?) partibus junioribus puberulis. Folia glabra breviter petiolata; petiolis 3 mm. longis; laminis suborbicularibus 3-4 cm. longis et fere aeque latis, supra nitidis (in sicco castaneis) subtus pallidis, venis non prominentibus, utrinque 3-5, paribus duobus infimis prominentioribus quam aliae et laminis speciem triplinervem dantibus, reticulo haud visibili; stipulis pubescentibus lanceolatis 5 mm. longis, basi crassa, parte superiore mox decidua. Cymae axillares foliis aequilongae, pedunculatae; pedunculis 1·5 cm. longis, pedunculis et ramis et pedicellis et calycibus puberulis, pedicellis 1-2 mm. longis. Calyx 1·5 mm. longus, anguste cupularis, obscure 4-dentatus. Corolla extus glabra 4 mm. longa, 4-lobatus, lobis quam tubo longioribus; tubo intus pubescenti. Stamina 4, antherae breviter exsertae, ca. 1·5 mm. filamentis aequilongae. Stylus 4 mm. longus; stigmate 1 mm. longo. Fructus ignotus.

Rigo District, Papua. Rev. R. Lister Turner.

Oleaceae.

JASMINUM TURNERI, n. sp. (Plate xvii.)

Frutex scandens glaber. Folia simplicia, breviter petiolata; petiolis 3-5 mm. longis; laminis ca. 8 × 3·5 cm., ellipticis ad basin subacutis vel fere rotundatis, ad apicem retuse acutis, prominenter trinervis, nervis basilaribus fere ad apices foliorum productis, venis lateralibus et venulis in foliis veterioribus exsiccatis prominentibus praecipue supra. Cymae ad apices ramorum brevium lateralium sitae, interdum 3-florae interdum laxe semel vel bis furcatae; pedunculis tenuis, 1-1·5 cm. longis, pedicellis tenuis, 2 cm. longis. Bracteae et bracteolae anguste lineares. Calyx cupularis, 2 mm. longus, 4-dentatus, dentibus 1 mm. longis. Corolla 10-12-lobata, tubo 1-1·3 cm. longo, lobis 2·5 × ·2 cm. Stamina tubi in parte superiore affixa; antheris 4 mm. longis. Stylus tenuus, 1·3 cm. longus; stigmate 3 mm. longo.

Rigo District, Papua. Rev. R. Lister Turner.

The present species is especially characterized by its trinerved leaves, long slender pedicels and many-lobed corolla; in these respects it approaches the Philippine *J. dolichopetalum* Merr. and Rolfe, but is quite distinct from that species in its broader and blunter leaves and other characters.

From the several trinerved or subtrinerved Indian species it is distinguished by its long slender pedicels.

Mr. Turner's collections also included specimens of *J. aemulum* R. Br., both glabrous and pubescent forms, and *J. didymum* Forst.

Apocynaceae.

Parsonsia velutina R. Br. Not previously recorded for the Territory.

We also have Papuan specimens in the Queensland Herbarium collected at Boku (leg. Mrs. H. P. Schlencker) and Port Moresby (leg. C. T. White).

P. velutina is widely distributed and very common in Eastern Australia. It exhibits considerable variation in regard to leaf shape, inflorescence and vestiture. Mr. Turner's specimens are represented by two sheets, the one with the typical deep rust-coloured, the other with a lighter coloured, denser and softer tomentum respectively.

Borraginaceae.

Ehretia microphylla Lam. (E. buxifolia Roxb.). Not previously recorded from the Territory.

Acanthaceae.

Thunbergia fragrans Roxb. Not previously recorded from the Territory. Probably naturalized.

Verbenaceae.

Premna nauseosa Blanco. (P. Dallachyana Benth.; P. Tateana Bail.). Not previously recorded from the Territory.

From a comparison of specimens of *P. Dallachyana* Benth. in the Queensland Herbarium from the type locality (leg. Rev. N. Michael) with specimens from the Philippines (ex. Herb. Bur. Science, Manila) of *P. nauseosa*, I feel convinced of the identity of the two plants. I feel convinced also, that *P. Tateana* Bail. is likewise referable here.

Petraeovitex Riedelii Oliv. Not previously recorded from the Territory.

Euphorbiaceae.

Glochidion Ferdinandi Muell. Arg. Type not previously recorded from the Territory, the var. *supra-axillaris* only, previously recorded. (C. T. White, *Proc. Roy. Soc. Queensland*, 34, p. 39).

Antidesma ghaesembilla Gaertn. Not previously recorded from the Territory.

Liliaceae.

Dianella laevis R. Br. Not previously recorded from Papua.

Mr. Turner's specimens are rather poor, but I have little hesitation in referring them to the above very common Australian species.

Commelinaceae.

Pollia sorzogonensis Endl. Not previously recorded from the Territory. The plant from Deva Deva (White, *Proc. Roy. Soc. Queens.*, 34, p. 17) recorded as *P. macrophylla* Benth. belongs here, the Mafula plant recorded at the same time represents the true *P. macrophylla*.

Aneilema nudiflorum R. Br. Not previously recorded from the Territory. The plant recorded in the *Queensland Agricultural Journal* (22, 1909, p. 150) by Bailey, from Boku (leg. Mr. H. P. Schlencker), as *Commelina ensifolia* R. Br. belongs here.

EXPLANATION OF PLATE XVII.

Above, *Jasminum Turneri*. Below, *Plectronia suborbicularis*.

THE TRICHOCERIDAE OF AUSTRALIA (DIPTERA).

By CHARLES P. ALEXANDER,
Massachusetts Agricultural College, Amherst, Massachusetts, U.S.A.
(Communicated by Dr. E. W. Ferguson.)

(Eleven Text-figures.)
[Read 28th July, 1926.]

The genus *Trichocera* was proposed by Meigen in 1803 for a group of small crane-flies that are eminently characteristic of winter conditions, being most commonly noted in late autumn, early spring and during mild sunny days in winter. For many years the genus was placed in close relationship to the Tipulid genus *Limnophila* Macquart but is now known to be only distantly allied to this genus. Even as recently as 1924, Pierre has placed the group as a subfamily of the Tipulidae. He has, moreover, included in this group the alpine fly, *Alfredia acrobata* Bezzi, which is almost certainly a degenerate species of *Limnophila* having nothing to do with the Trichoceridae. From a study of the larva and pupa, the writer (Alexander, 1920) removed *Trichocera* from the Tipulidae and placed it as a subfamily, the Trichocerinae, of the family Anisopodidae. Still more recent work on the morphology of the adult flies has demonstrated that *Trichocera* and the allied genera are more isolated than was hitherto believed and they are now more generally conceded to represent a distinct family, the Trichoceridae (Crampton, 1924, 1925). The writer believes the superfamily Tipuloidea should include the following elements:

Psychodidae, with the subfamilies Bruchomyiinae, Phlebotominae and Psychodinae.
Tanyderidae.
Ptychopteridae.
Tipulidae, with the subfamilies Limoniinae, Cylindrotominae and Tipulinae.
Trichoceridae.

Of these families, the Psychodidae, Tanyderidae and Ptychopteridae form a closely related group, the Tipulidae a second, and the Trichoceridae a third that leads toward the Anisopodidae.

Three genera of Trichoceridae have been described, the dominant genus of the Holarctic region being *Trichocera* (genotype, *hiemalis* De Geer) with a large number of described species whose synonymy is still badly involved. A few species occur in the higher mountains of the Oriental region and very recently Edwards (1923) has described a species, *T. antarctica* Edwards, from Campbell Island of the Subantarctic Islands of New Zealand, the first true *Trichocera* from the Southern Hemisphere. It should be noted that the European *Trichocera annulata* Meigen occurs in New Zealand and Victoria where it has presumably been carried by modern transportation, the immature stages of the various species often occurring in stored roots and tubers where they may cause some secondary injury (Rhynehart, 1925).

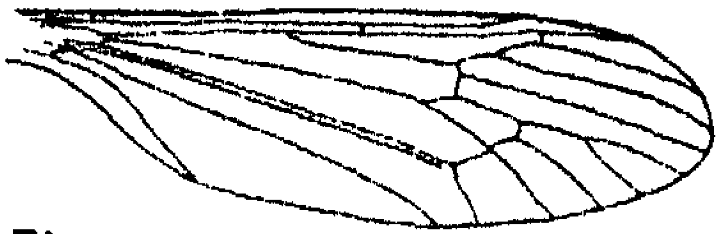

Fig. 1

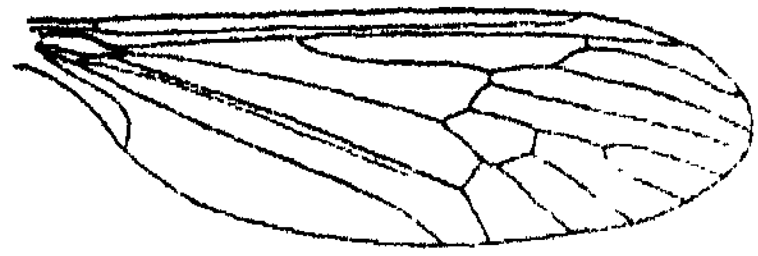

Fig. 2

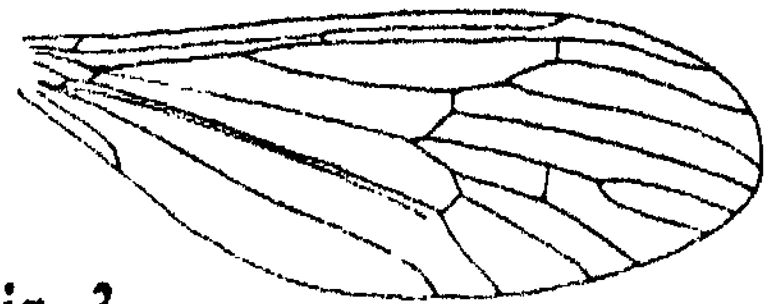

Fig. 3

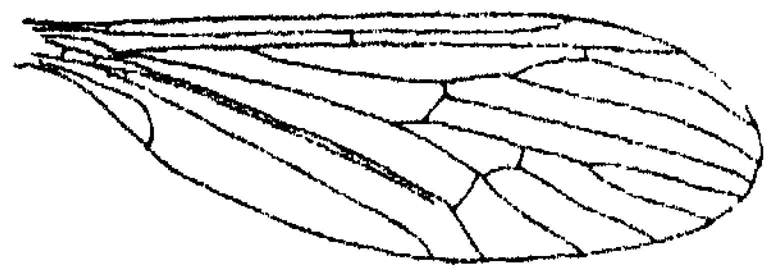

Fig. 4

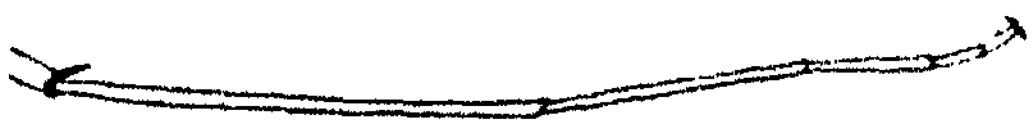

Fig. 5

Fig. 6

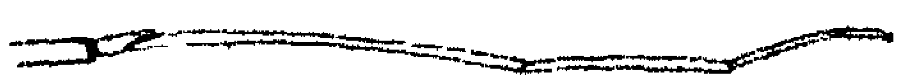

Fig. 7

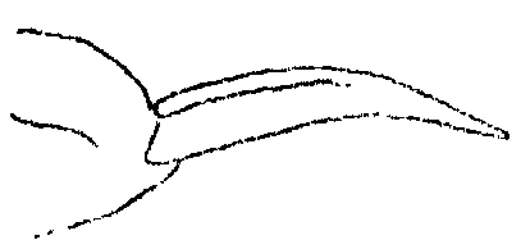

Fig. 8

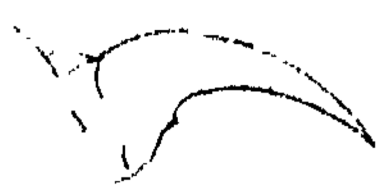

Fig. 10

Fig. 9

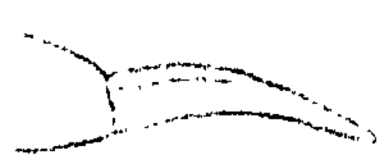

Fig. 11

Fig. 1. Wing of *Diazosma subsinuata* Alexander.
Fig. 2. Wing of *Trichocera hiemalis* De Geer.
Fig. 3. Wing of *Paracladura maori* Alexander.
Fig. 4. Wing of *Nothotrichocera cingulata*, n. sp.
Fig. 5. Tarsus of *Trichocera hiemalis* De Geer.
Fig. 6. Tarsus of *Nothotrichocera cingulata*, n. sp.
Fig. 7. Tarsus of *Paracladura maori* Alexander.
Fig. 8. Ovipositor of *Nothotrichocera tonnoiri*, n. sp.
Fig. 9. Ovipositor of *N. cingulata*, n. sp.
Fig. 10. Ovipositor of *N. terebrella*, n. sp.
Fig. 11. Ovipositor of *N. tasmanica*, n. sp.

The second genus to be described, *Diazosma* Bergroth (genotype, *hirtipennis* Siebke) includes one or two Holarctic species. The flies are very rare and there is still some question as to whether the Nearctic species, *subsinuata* Alexander, is identical with the genotype of Europe. Since the ranges of most of the other known species of the family are so very restricted, since the differentiation of species is often based on relatively slight characters of the male hypopygium, and since several species of a given genus may occupy a small area, it seems advisable to retain the two names until more data become available and a direct comparison of specimens can be made.

The third genus, *Paracladura* Brunetti, was proposed in 1911 (genotype, *gracilis* Brunetti) under the erroneous impression that the fly was allied to the Eriopterine Tipulid genus *Cladura*. The genus now includes 11 species from New Zealand, 1 from the Auckland Islands, 2 from Formosa and Southern Japan, 2 from the Himalayas and 1 from the western United States. *Paracladura* may be expected to occur in Eastern Australia.

Upon his recent expedition to Tasmania, Mr. A. L. Tonnoir secured specimens of Trichoceridae which were kindly submitted to me for study. The four species of these flies taken in Tasmania prove to represent a new genus, *Nothotrichocera*, that curiously combines certain features of *Trichocera* and *Paracladura*. These species of *Nothotrichocera* and the records of *Trichocera annulata* Meigen for Victoria constitute the first references to the family in Australia. The types of the new species have been returned to Mr. Tonnoir.

Key to the Genera of the Trichoceridae.

1. Wings with vein 2nd A subsinuate, not short and curved abruptly into the anal angle (Fig. 1) .... *Diazosma* Bergroth
   Wings with vein 2nd A short, curved abruptly into the anal angle 2
2. Tibial spurs present (Fig. 5); tarsi with the basitarsus longer than segments 2 and 3 taken together (Figs. 2, 5) .... *Trichocera* Meigen
   Tibial spurs lacking (Figs. 6, 7); tarsi with the basitarsus shorter than tarsal segment 2 3
3. Basitarsus very short, only about two to three times as long as wide, shorter than the third tarsal segment (Fig. 7); wings with *m-cu* on M_4 some distance beyond the origin of the latter; M_{3+4} shorter than the basal section of M_3, the latter forming the caudal border of cell 1st M_2 (Fig. 3) .... *Paracladura* Brunetti
   Basitarsus long, about ten times as long as wide, longer than the third tarsal segment (Fig. 6); wings with *m-cu* on M_{3+4} close to its fork; M_{3+4} long, the basal section of M_3 correspondingly reduced and forming the outer end of cell 1st M_2 (Fig. 4) .... *Nothotrichocera*, n. gen.

NOTHOTRICHOCERA, n. gen.

Characters as in the family. Legs with the tibial spurs lacking; basitarsi shorter than tarsal segment 2 but longer than tarsal segment 3, the segments beyond the second gradually decreasing in length. Wings with a venation that is much as in *Trichocera* but with cell 1st M_2 narrower and the inner end more pointed; *m-cu* close to the outer end of M_{3+4}, the basal section of M_3 taking part with *m* in forming the outer end of cell 1st M_2. Ovipositor with compressed, relatively horny, down-curved valves.

Genotype, *Nothotrichocera tonnoiri*, n. sp. (Australasian Region).

Key to the Species of Nothotrichocera.

1. Size large (wing, ♀, over 6 mm.) 2
   Size small (wing, ♀, under 5 mm.) 3

2. Pronotum dark brown; petiole of cell M_1 less than twice the length of *m*; abdominal tergites dark brown, the extreme caudal margins of the segments narrowly blackened; ovipositor with the valves elongate, only gently curved to the subacute tips (*Fig. 8*) .... *tonnoiri*, n. sp.
   Lateral angles of the posterior pronotum broadly fulvous-yellow; petiole of cell M_1 three or more times the length of *m* (*Fig. 4*); abdomen dark brown, the segments broadly ringed caudally with yellowish testaceous; ovipositor with the valves short, strongly curved, gradually narrowed to the acute tips (Fig. 9) .... *cingulata, n. sp.*
3. Wings tinged with greyish; knobs of the halteres tipped with obscure yellow; ovipositor with the valves yellowish horn-colour, very compressed, strongly curved to the needle-like points (Fig. 10) .... *terebrella*, n. sp.
   Wings tinged with brownish; knobs of halteres entirely dark brown; ovipositor with the valves dusky horn-colour, of moderate width only, curved gently to the subacute tips (Fig. 11) .... *tasmanica*, n. sp.

NOTHOTRICHOCERA TONNOIRI, n. sp.

♀. Length about 5-5·3 mm.; wing 6·2-6·3 mm.

Rostrum and palpi dark brown. Antennae filiform, dark brown, the second scapal segment somewhat paler apically; flagellar segments elongate-cylindrical, the first a little longer than the second, the succeeding segments very gradually increasing in length. Head obscure brownish-yellow, the centre of the vertex darker.

Pronotum dark brown. Mesonotal praescutum gibbous, dark brown, broadly paler laterally; scutal lobes dark brown, the median area and the parascutella paler; scutellum darker brown; postnotum obscure brownish-yellow. Pleura obscure yellow, variegated with brown, especially on the sternopleurite, anepisternum and the meron. Halteres relatively elongate, pale, the knobs dark brown. Legs with the coxae brownish testaceous, the outer faces somewhat darker; trochanters brownish-yellow; femora brown, their bases paler; tibiae and tarsi dark brown; basitarsus about two-thirds the length of tarsal segment 2 and about one-half longer than tarsal segment 3; tarsal segment 4 two-thirds or less of segment 3; segment 5 shortest, a little less than one-third segment 4. Wings with a strong brownish tinge, the stigmal region slightly darker brown, oval; veins dark brown. Venation: Sc_2 shortly before midlength of Rs; Sc_1 ending some distance before *r*; basal section of R_2 and terminal section of R_1 subequal; inner end of cell 1st M_2 acutely pointed; petiole of cell M_1 short, only a little longer than *m*; *m-cu* close to the outer end of cell 1st M_2; vein 2nd A short, only gently curved to the margin.

Abdominal tergites dark brown, the extreme caudal margins of the segments narrowly blackened; sternites paler brown. Ovipositor (Fig. 8) horn-coloured, with the valves elongate, only gently curved to the subacute tips.

Hab.—Tasmania.

Holotype, ♀, Mt. Wellington, November 25, 1922 (A. Tonnoir).

Named in honour of the distinguished student of the Diptera of Australia and New Zealand, André L. Tonnoir, to whom I am indebted for many kind favours.

NOTHOTRICHOCERA CINGULATA, n. sp.

Very similar in size and general appearance to *N. tonnoiri*, n. sp., differing as follows.

Lateral angles of the posterior pronotum broadly fulvous-yellow. Wings with the basal section of R_2 about one-third shorter than the terminal section of R_1; petiole of cell M_1 about three or more times the length of

m; vein 2nd A rather strongly incurved to the margin (Fig. 4). Abdomen dark brownish-black, the segments broadly ringed caudally with obscure yellowish testaceous. Ovipositor (Fig. 9) with the valves shorter, gradually narrowed, strongly curved to the acute tips.

Hab.—Tasmania.

Holotype, ♀, Mt. Wellington, November 28, 1922 (A. Tonnoir).

NOTHOTRICHOCERA TEREBRELLA, n. sp.

♀. Length about 3·6 mm.; wing 4·6 mm.

Rostrum and palpi dark brown. Antennae dark brown, with the second scapal segment pale apically. Head obscure yellow, slightly darker dorsomedially.

Pronotum dark brown, the anterolateral pretergites paler. Mesonotum relatively uniformly dark brown, the praescutum scarcely paler laterally; scutellum more yellowish testaceous, with a small median spot at base. Pleura pale brown, variegated with darker brown on the mesopleura and meron. Halteres with the apices of the knobs obscure yellow. Legs brown, relatively slender; basitarsus relatively short, only about one-half the second segment which is longer than the segments beyond it taken together; third tarsal segment nearly twice the length of the fourth. Wings with a greyish tinge, the veins dark brown. Venation: Almost as in typical *Trichocera*; petiole of cell M_1 fully three times *m*.

Abdomen dark brown, the genital segment paler. Ovipositor (Fig. 10) with the valves yellowish horn-colour, very compressed, strongly curved to the needle-like tips.

Hab.—Tasmania.

Holotype, ♀, St. Patrick's River, altitude 1,200 feet, November 1, 1922 (A. Tonnoir).

NOTHOTRICHOCERA TASMANICA, n. sp.

♀. Length about 3·3 mm.; wing about 4·5 mm.

Generally similar to *N. terebrella*, n. sp.

Praescutum and scutum dark brown medially, paler laterally. Pleura testaceous, scarcely variegated with darker. Knobs of the halteres entirely dark. Wings with a brownish tinge. Venation: Sc_2 shortly beyond one-third the length of Rs; basal section of R_2 longer than the terminal section of R_1; petiole of cell M_1 nearly three times *m*.

Abdomen dark brown. Ovipositor (Fig. 11) with the valves dusky horn-coloured, compressed, of moderate width only, very gently curved to the subacute tips.

Hab.—Tasmania.

Holotype, ♀, King River, altitude 500 feet, February 4, 1923 (A. Tonnoir).

Trichocera annulata Meigen.

(*Trichocera annulata* Meigen, *Syst. Beschreib.*, 1, 1818, 215.)

Victoria: Melbourne, 11th August, 1918, 28th June, 1925 (G. F. Hill). Tyers, 24th May, 1925 (Miss Galbraith).

In the collection of the National Museum, Victoria.

As stated above, this European species was probably introduced in stored vegetable products or, possibly, in manure.

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A NEW CLASSIFICATION OF AUSTRALIAN ROBBERFLIES BELONGING TO THE SUBFAMILY DASYPOGONINAE (DIPTERA, ASILIDAE).

By G. H. HARDY,
Walter and Eliza Hall Fellow in Economic Biology,
Queensland University, Brisbane.

(Four Text-figures.)

[Read 30th June, 1926.]

In these PROCEEDINGS for the year 1921, I drew attention to the fact that published characters were inadequate for the purpose of placing most of the Australian Dasypogoninae in their correct genera and an outline of some of the characters that could be used for the purpose was given. The various errors that were made in that attempt to reclassify the Dasypogoninae are amended here, where it will be noted that various species are transferred from one genus to another whilst other modifications are suggested.

Considerable delay and many difficulties have been experienced in the progress of this work, for it is not always easy to recognize Australian robberflies from the descriptions so far published. Confusion has been caused by certain specimens that are reputed to be authentically named, but probably had never been examined by the authorities under whose names they are standing. At most these had been compared with authentic specimens or were those retained out of a small series, some of which had been subsequently submitted for identification, the name thus secured, but the specimens themselves were never recovered. Under the latter circumstances names received have been attached to allied species or to others that have a superficial resemblance to those submitted for identification. A supposed specimen of *Neosaropogon nigrinus* Ricardo, in the collection of Mr. F. H. Taylor, agrees with the genus as defined by Miss Ricardo, but apparently it is an undescribed species belonging to or near *Rachiopogon*, whilst the Australian Museum possesses a further specimen bearing the same name, originally also from Mr. Taylor's collection, and this is the female of *Ommatius angustiventris*, one of the subfamily Asilinae.

Although correctly identified in collections, other specimens are a source of error as they do not correspond to the published characters and hence may be ignored as unreliable with regard to their identity. *Neosaropogon princeps* is such an example; the genus as defined by Miss Ricardo and compared with the specimen misidentified as *N. nigrinus* in Mr. Taylor's collection, did not agree with characters of the typical species and I have therefore only recently accepted the identification.

The present classification has been advanced by including the outstanding characteristics of the female genital armature. The presence of spines has long been recognized in some of the genera. Miss Ricardo mentions them in the descriptions of certain species and in his "Diptera Danica" Lundbeck referred to them under genera containing them, but Dakin and Fordham overlooked these

and other references when they applied the character as of generic value on Australian material. In the present paper the presence of these spines is regarded as a tribal character.

All the Australian Apioceridae, Mydaidae and part of the Therevidae and Asilidae are furnished with these spines in the female genital armature. These spines are characteristic of nearly all the ground-frequenting flies of these four families and they occur occasionally in genera, like *Laphria*, the species of which are not so addicted to low flight.

Although this paper deals mainly with genera, certain notes pertaining to species are included. Besides recording the position of certain species, as far as has yet been ascertained, that have been hitherto misplaced generically, some male genitalia are described.

It is proposed to revise each genus, treating more fully with specific characters at some future time, but the identities of so many species are yet in doubt and so many names are outstanding, that several years must pass before even a reliable and comprehensive catalogue of the Australian Robberflies can be compiled.

I am indebted to Dr. I. M. Mackerras for drawing attention to the occurrence of thoracic spines in the genus *Codula*, the presence of which seems to have been overlooked by previous authors; to Dr. E. W. Ferguson for information acquired by him; and to Dr. C. Anderson, Mr. H. A. Longman and Mr. E. R. Waite, Directors, and to Mr. J. A. Kershaw and Mr. J. Shewan, Curators, respectively of the Australian, Queensland, South Australian, National and Macleay Museums, for access to the material under their charge, much of which has been on loan over long periods.

Subfamily Dasypogoninae.

The characters whereby this subfamily is to be recognized consist of the open marginal cell (at most this is closed at the wing margin, never before it) and of the broad wing, the anal area always being present, never absent as in the subfamily Leptogastrinae. It has long been recognized that these characters do not indicate a true affinity between any two genera containing them and certain genera may be more closely allied to others excluded from the subfamily. Amongst the Australian material there are three very well defined groups of the Dasypogoninae as here understood, each of which is given a tribal name, namely *Brachyrrhopalini*, *Saropogonini* and *Phellini*; the last of these has affinities with the subfamily Laphrinae. Several genera, mainly *Clinopogon* and *Deromyia*, may ultimately be withdrawn from their respective tribes and associated with other genera not here dealt with if the main scheme be developed so as to include the genera of the world.

Some authors would treat the Leptogasterinae as part of the Dasypogoninae and under these circumstances it would rank as a fourth tribe *Leptogasterini*, associated with the *Brachyrrhopalini*, whilst Laphrinae might be reduced to tribal value including only the genus *Laphria* in Australia; the other genera of this region would form yet another tribe, as they are without the spines in the female genital armature.

As far as I have yet been able to trace the characters, the subfamily Asilinae forms a group apart; none of the genera are allied to other groups and in rare cases when the female is provided with genital spines, these differ from those of the *Brachyrrhopalini* and *Phellini* in position and in structure.

The characters of the tribes here dealt with and the association of the genera contained within them, are given in the key below. Several genera are grouped

under various couplets, and, although our present knowledge indicates ways whereby some of these may be isolated, this procedure is not followed in the present instance as future study will probably show more decisive characters that may be used for the purpose. This especially applies to the *Saropogonini* where the details of the antennae, the chaetotaxy and perhaps the male genitalia will help.

Key to the tribes and genera of the Dasypogoninae.

1. Female genital armature furnished with a paired row of spines 5
   Female without these spines .... BRACHYRRHOPALINI. 2
2. Thorax with a pair of lateral spines, one placed on each side a little above the wings 3
   Thorax without such spines; antennae with three segments and a minute spine; anterior tibiae with a spur .... *Brachyrrhopala* Macq.
3. Anterior tibiae with an apical spur 4
   Anterior tibiae without this spur; antennae with three segments and a minute spine .... *Codula* Macq.
4. Antennae with four segments and a minute spine .... *Chrysopogon* Roder.
   Antennae with three segments and a strongly developed spine .. *Opseostlengis* White.
5. Wings with the fourth posterior cell open, at most closed at the wing margin. .... SAROPOGONINI. 6
   Wings with the fourth posterior cell closed considerably before the wing margin. .... PHELLINI. 8
6. Antennae with the fourth segment present and in addition with a small apical segment or a minute spine 7
   Antennae with three segments and a minute spine; with spur on the anterior tibiae ...... *Neocyrtopogon* Ric., *Rachiopogon* Ric., *Gen. ?* (part of the old *Neosaropogon*).
7. With spur on the anterior tibiae ...... *Erythropogon* White, *Questopogon* Dakin and Fordham, *Neosaropogon* Ricardo, *Saropogon* Loew.
   Without spur on the anterior tibiae ...... *Neodioctria* Ricardo, *Stenopogon* Loew, *Cryptopogon* White, *Clinopogon* Bezzi.
8. Antennae with three segments and a minute spine; with spur on anterior tibiae. .... *Deromyia* Phillippi.
   Antennae with four segments and a minute spine or a style; without spur on anterior tibiae .... *Phellus* Walker, *Psilozona* Ricardo, *Bathypogon* Loew.

Tribe Brachyrrhopalini (new tribal name).

To this tribe belong all the Australian genera in which the female genital armature is without a row of spines; the antennae bear at the apex a spine that is minute in all except one genus; the fourth posterior cell is always open and the abdomen, though not necessarily club-shaped, is narrower at the base than at some more remote point. The genera placed here constitute a homogeneous group.

Genus BRACHYRRHOPALA Macquart.

Macquart, *Dipt. Exot.*, suppl. 2, 1847, 36.—*Cabasa* Walker, *Ins. Saund.*, Dipt. ii, 1850, 100.

Synonymy.—I can see no justification for maintaining *Cabasa* as a distinct genus; all the characters of the only species hitherto placed therein are identical with those of *Brachyrrhopala*.

Note.—The species belonging to this genus are *Dasypogon* (*Cabasa*) *pulchella* Macquart, *Brachyrrhopala ruficornis* Macquart, *Codula fenestrata* Macquart and others yet unidentified. *Brachyrrhopala maculata* Roder and *B. fulva* Ricardo (= *? Codula quadricincta* Bigot) undoubtedly belong here. *Dasypogon maculinevris* Macquart and *D. limbipennis* Macquart, both of which have been placed by some authors in this genus, are now referred to *Erythropogon*. *Brachyrrhopala bella* White is a *Saropogon* and *Dasypogon* (*Brachyrrhopala*) *nitidus* Macquart belongs to *Neosaropogon*.

Tribe Saropogonini (new tribal name).

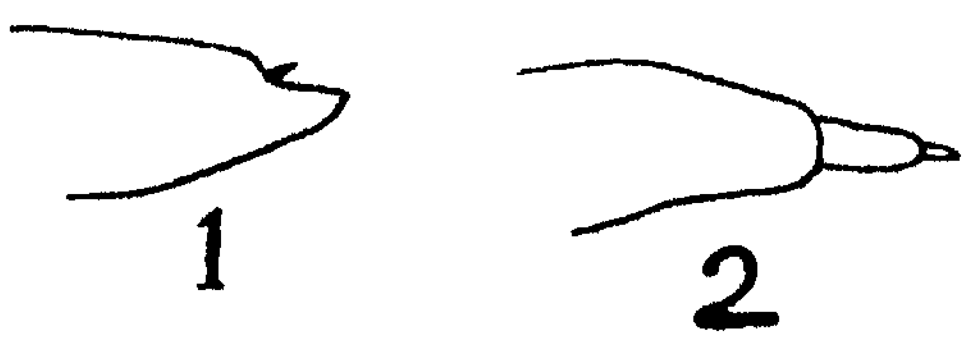
The eight genera placed in this tribe can be readily divided into three groups, all of which have the female provided with about twelve easily detected spines arranged in two rows symmetrically placed at the apex of the abdomen. The antennae are provided with a minute spine similar to those found in the previous tribe, the only exception being on *Clinopogon* Bezzi (Text-fig. 1). The tribe needs further study for the purpose of determining which characters can be used best for separating such genera as are here grouped. No attempt has yet been made to use the few bristles of the thorax for the purpose although these promise to be of assistance. In the meanwhile the antennal structure of *Clinopogon*, the extra cross-vein in the wing of *Cryptopogon* and the specialized male genitalia of *Stenopogon* are the only definite characters whereby these genera may be isolated.

Genus Rachiopogon Ricardo.

When my previous paper was written the characters of this genus were unknown to me. I have since found that they are the same as those given then for the genus *Neosaropogon*. Only one species has been placed hitherto in this genus and to it I am adding for convenience some forms that may ultimately be placed in a new genus. *Dasypogon carbo* Walker, the type of which, according to Miss Ricardo, is probably lost, is an easily recognized black species with the fourth and fifth segments of the abdomen red. It is placed here with the specimen from Mr. F. H. Taylor's collection erroneously named *Neosaropogon nigrinus*; several others of uncertain identity also belong here.

Genus Erythropogon White.

The fourth segment of the antennae is present, though often difficult to detect, in the typical species of this genus. *Dasypogon* (*Brachyrrhopala*) *limbipennis* Macquart belongs here, despite the fact that the antennae are abbreviated. Both species of this genus range from Tasmania to Queensland.



Text-fig. 1. Apex of the antennae in genus *Brachyrrhopala*.
Text-fig. 2. The same in *Clinopogon sauteri* Bezzi.

Genus Questopogon Dakin and Fordham.

In the South Australian Museum there are two specimens that I believe belong to this genus. The general shape is that of *Rachiopogon carbo* Walker. The difference given between this genus and *Neosaropogon* by Dakin and Fordham will, of course, not hold, as those authors copied the erroneous characters of the latter as given by Miss Ricardo. The specimens placed here are from Ooldea (A. M. Lea) and Murray River (H. S. Cope), South Australia, and they compare very favourably with the description of the typical form.

Genus Neosaropogon Ricardo.

I have misunderstood this genus for many years. The generic characters given by Miss Ricardo did not agree with specimens identified as *N. princeps* in

collections. A supposed authentic specimen of *N. nigrinus* Ricardo, in Mr. Taylor's collection, did so conform, thus misleading me. In the National Museum there is an authentic specimen of *Dasypogon carus* Walker, which name is a synonym of *N. princeps* Macquart and which is identical with specimens identified as the typical form in most other collections.

N. princeps Macquart is the only species of those originally placed here that can be allowed to remain in the genus. *Dasypogon* (*Brachyrrhopala*) *nitidus* Macquart also belongs here, *Dasypogon sergius* and *D. festinans* Walker apparently being synonyms of this species.

Dasypogon salinator Walker, *N. froggatti* Dakin and Fordham (the latter I have recognized in the South Australian Museum collection) and also, perhaps *N. claripennis* and *N. nigrinus* Ricardo, must be removed to another position which is indicated in the key, near *Rachiopogon*.

Genus Saropogon Loew.

Saropogon rubescens White, *Brachyrrhopala bella* White, and probably *Dasypogon suavis* Walker, belong here.

Genus Stenopogon Loew.

The globular appearance of the male genitalia in this genus is due to the presence of a large dorsal plate overhanging the upper forceps. This is characteristic of the genus as far as the Australian material is concerned, but is replaced by a somewhat similar ventral plate on my specimen of the typical species, *N. sabaudus* Fab., supplied by Prof. M. Bezzi. Provided the genitalia on the latter have not been reversed, the Australian species will have to be removed from this genus.

S. elongatus Macquart appears to be the species on which this dorsal plate is produced into a downwardly projecting curved apical process that becomes bilobed at the apex (Text-fig. 3). Another species has this plate simple. The specimen identified by White as *S. nicoteles* Walker, conforms nearest to that illustrated but may not be identical, as the apex is hidden between the forceps.

Genus Clinopogon Bezzi. (Text-fig. 2).

The type of this species, *C. sauteri* Bezzi, is from New Guinea and I am indebted to Prof. Bezzi for a pair. The antennae, here illustrated, do not conform to the usual type of the Saropogonini in so far as the apical segment is not reduced to a spine. Two Australian species, both apparently undescribed, are known to me.

Tribe Phellini (new tribal name).

The genital spines of the female are not always easily detected on dried specimens. Their number is in excess of those found on specimens of the tribe *Saropogonini* and they are shorter. The closed fourth posterior cell, however, will always indicate this tribe when characters of the genital armature are doubtful. The genus *Deromyia* will not be maintained in this tribe when the relationship to the other genera of the world has been ascertained. The other three genera are certainly closely allied.

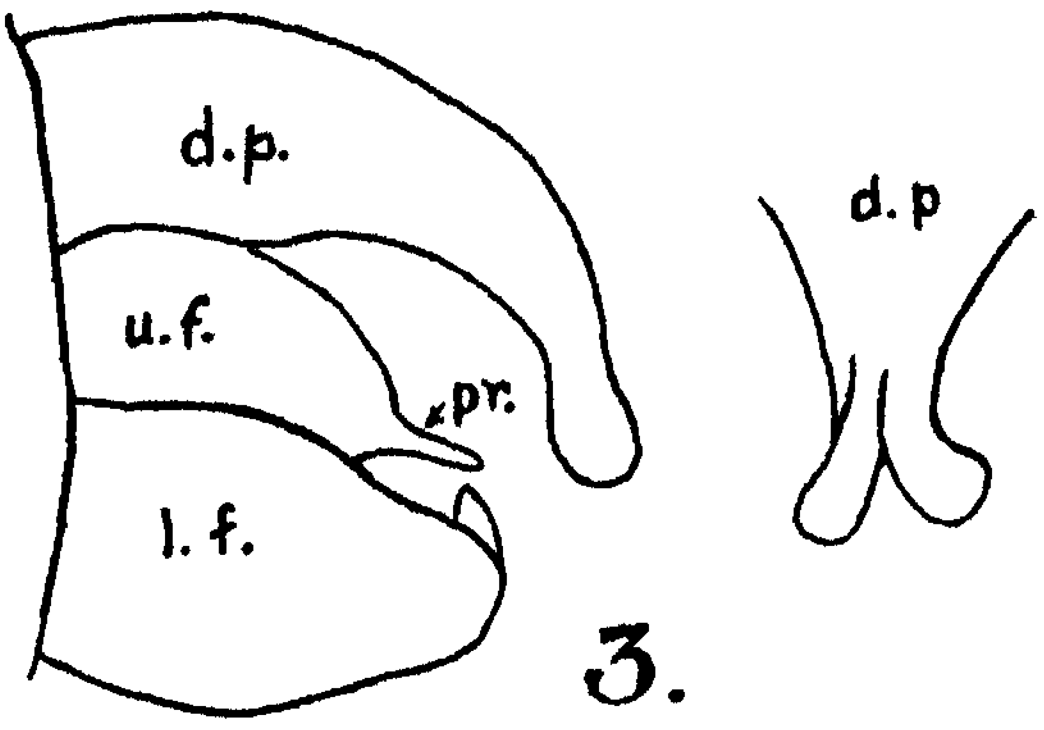
Genus Phellus Walker.

In my previous paper two forms of this genus were referred to and the supposed sexes allied. Since then these sexes are found to be distinct species so

that four forms are represented in all. One has been named *P. piliferus* Dakin and Fordham; the typical form, *P. glaucus* Walker, has what its author calls "tips of the middle shanks hooked" and which Miss Ricardo referred to as "curious prolongation of the middle tibia"; probably *P. piliferus* also has this character, which has been regarded as of generic importance and is not mentioned in the specific description. The other two forms are respectively similar to those described, but the tibial character is missing in each case; it is possible this may be no more than a variation.

Genus PSILOZONA Ricardo.

This genus is represented in the South Australian Museum by a series of nine specimens from Fortescue River, Hammersley Range, North-west Australia (W. D. Dodd). These specimens agree in all details with *P. albitarsis* and *P. nigritarsis* Ricardo, and can be divided on the same characters, but probably they do not represent more than one species. I know of no characters that would adequately separate this genus from *Phellus*, but the two cannot be confused owing to the great disparity in size.



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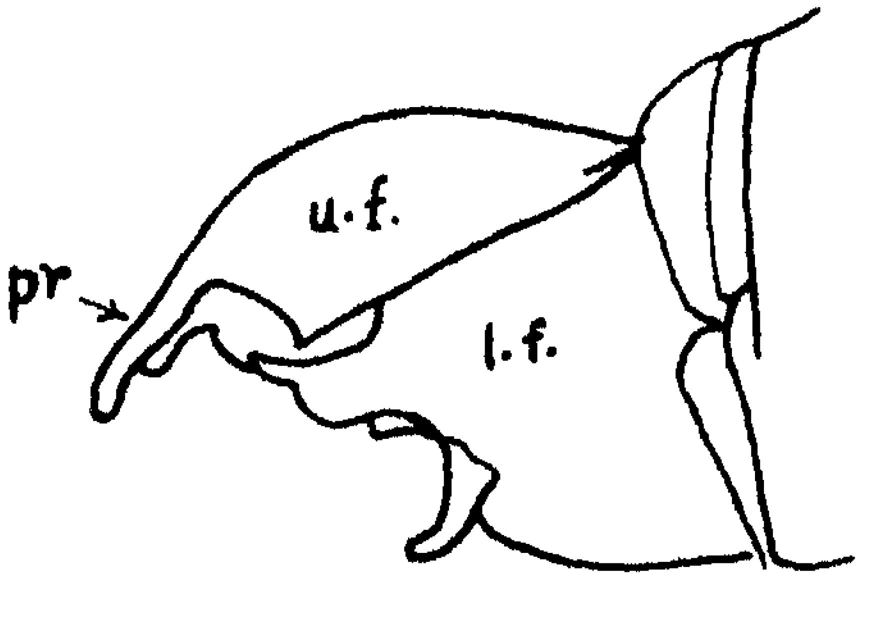

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Text-fig. 3. The male genitalia of *Stenopogon elongatus* Macquart, together with a view of the dorsal plate, seen from the rear but slightly askew.

Text-fig. 4. The male genitalia of *Bathypogon brachypterus* Macquart. *d.p.*, dorsal plate; *l.f.*, lower forceps; *u.f.*, upper forceps; *pr.*, process at the apex of the upper forceps.

Genus Bathypogon Loew.

Species of this well known Australian genus are met with in quantities settled on or flying over bare sandy patches of ground in the bush, on tracks and on roadways. The relative shortness of the wing is a unique character as far as Australia is concerned, thus making them recognizable at a glance, and the apex of the fourth antennal segment containing a small style, as in *Clinopogon*, also differentiates the genus from *Phellus* and *Psilozona*. Another genus, one of the Saropogonini yet to be named, has similar habits and general appearance but the wings are of normal length; it is readily mistaken for *Bathypogon* in the field.

The generic name was proposed by Loew for a species he described as *B. asiliformis*, but the work in which the descriptions appear does not seem to be in any Australian library and in consequence I have not been able to consult the original references. Of the twelve species that have been referred to this genus and that are contained in the following list, *asiliformis* and *plumbeus* must be omitted from the present discussion, as I have insufficient information concerning them.

Dasypogon brachypterus Macquart, 1838.
Dasypogon pedanus Walker, 1849.
Dasypogon aoris Walker, 1849.
Dasypogon boebius Walker, 1849.
Bathypogon asiliformis Loew, 1851.
Dasypogon testaceovittatus Macquart, 1854.
Proctocanthus posticus Walker, 1855.
Asilus mutilatus Walker, 1855.
Bathypogon maculipes Bigot, 1878.
Bathypogon nigrinus Ricardo, 1912.
Bathypogon tristis White, 1913.
Dasypogon plumbeus Fabr., placed here on the suggestion of Loew.

D. brachypterus and *B. nigrinus* are the only species described as having black hairs in the moustache, all the others having white or yellow hairs. Of these two the former has a few black hairs above the otherwise light moustache, the latter has black hairs and white ones. On this character alone *B. nigrinus* can be readily recognized, the black bristles occupying the central portion of the tubercle, white ones surrounding them.

Subsequent descriptions of *B. brachypterus* refer to the black bristles being absent, and what is believed to be this form, or at least *P. posticus* Walker, which is placed as a synonym by Miss Ricardo, is here illustrated (Text-fig. 4). Macquart's second reference under this name, a small male only 10 mm. long from Tasmania, I have no hesitation in referring to a distinct species that I have not seen from the mainland.

B. maculipes Bigot is evidently a distinctive species, one of very large size (22 mm.), but it is possible that more than one form has been referred to under the name.

Walker's three species, *mutilatus*, *boebius* and *pedanus* are described in such a way as to appear but one form, as also *aoris* when amended by Miss Ricardo's remarks concerning the type.

Another form that stands distinct according to the original description is *testaceovittatus*.

White referred to two Tasmanian species only, one being described as having a yellow moustache, or with black hairs above (*brachypterus*) and is more robust than the other which is further distinguished by a white moustache with a few

black bristles above (*nigrinus*). *B. nigrinus* certainly does occur in Tasmania, but I do not know if this is the form White had before him. *B. brachypterus* I have not seen from there.

The male genitalia of six species belonging to this genus are readily recognizable. *B. brachypterus* Macquart has an apical process on the upper forceps. That known as *B. nigrinus* Ricardo has simple upper forceps whilst a third form identified by White as *B. aoris* Walker, has a ventral lobe on these forceps. *B. tristis* White and another from the Eastern side of Australia have a type of genitalia similar to, but shorter than that of *B. nigrinus*, whilst a new species from Tasmania has a small projection emerging at the apex between the forceps.

It is difficult to make further progress with regard to the specific identity of the species in this genus in Australia. *B. tristis* White is the only type available, this being in my own collection, and it is very evident that there has been considerable confusion caused by the inadequate treatment given in the various descriptions. There are evidently many species to be found in Australia, all of them having the same superficial appearance, but very readily distinguished from each other on genital characters of the male and to a certain extent on colour characters. They are not well represented in collections numerically although they are amongst the more abundant robberflies to be found in the field. The distribution of the genus is interesting zoogeographically, apparently being limited to Australia and South America. Four species from Chili have been placed here.

DESCRIPTION OF A NEW SPECIES OF *DIURIS* FROM BARRINGTON TOPS, N.S.W.

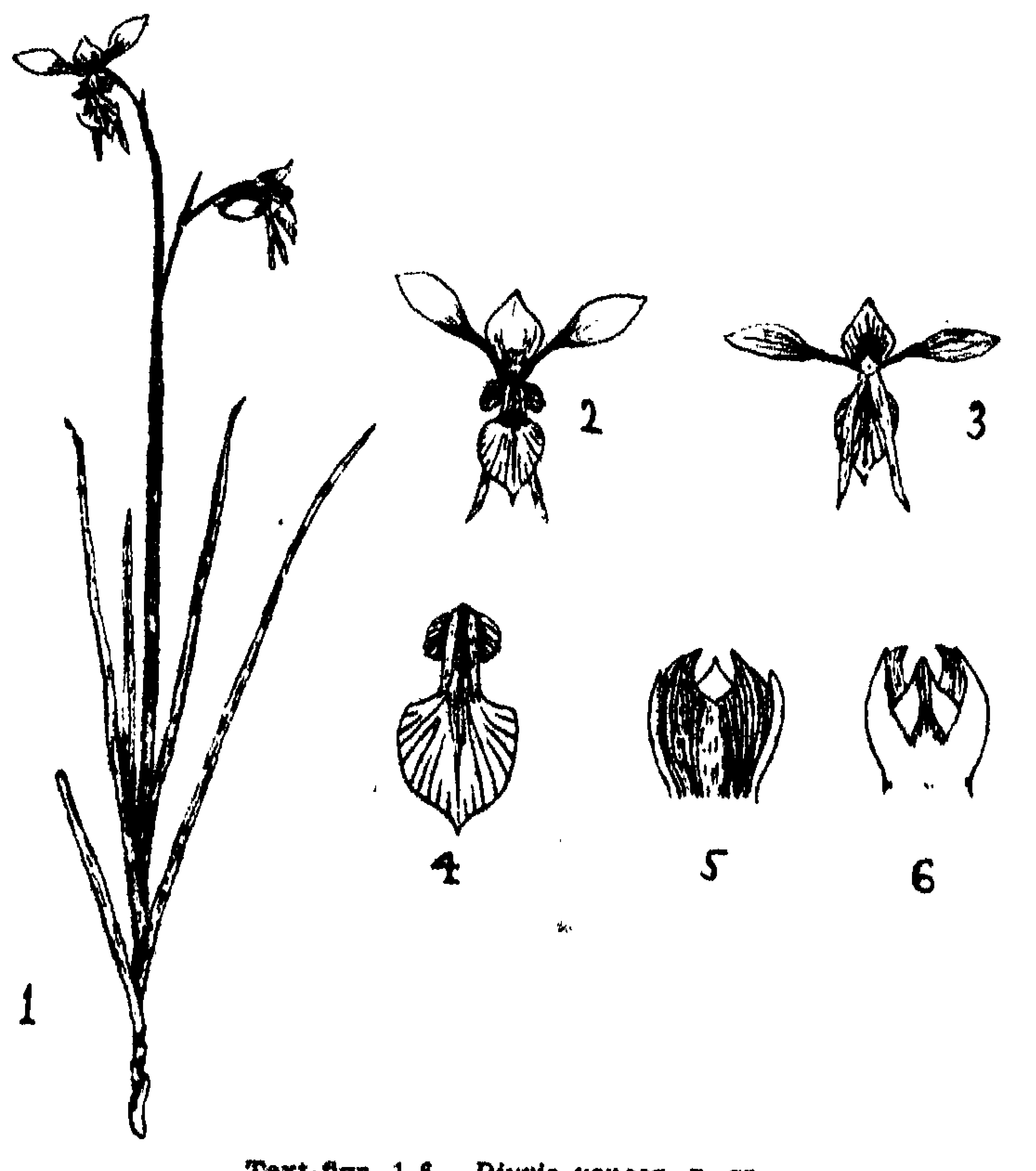
By Rev. H. M. R. Rupp.
(*Communicated by Mr. E. Cheel.*)

(Six Text-figures.)

[Read 25th August, 1926.]

Diuris venosa, n. sp.

Planta aliquantum robusta, glabra, 10-40 cm. alta, cum caule fusco. Folia 3-6, linearia, erecta vel patentia, 6-12 cm. longa. Flores 2-3, interdum plures, ravae-caerulae cum venis et notationibus purpureis-bruneis. Sepalum dorsale circiter 12 mm. longum, latum et fere hebes. Sepala lateralia 20 mm. longa, parallela,



Text-figs. 1-6. *Diuris venosa*, n. sp.

1. A small plant (half natural size). 2. Flower, front view. 3. Flower, back view. 4. Labellum from above, enlarged. (In the flower from which this was drawn, and which was the least damaged by heat and transit, the mid-lobe was narrower than usual). 5. Column from the front, enlarged. 6. Column from the back, enlarged.

cum marginibus incurvis. Petala patentia cum petiolis fuscis. Labellum sepalo dorsali longius: lobus intermedius spathulatus, venosus in longitudinem: lobi laterales prominentes, cum marginibus crenulatis. Columna brevis et lata, anthera acuta.

Comparatively robust, though appearing slender when dried. Plant from 10 to as much as 40 cm. high, with a dark stem, scaly at the base. Leaves linear, channelled, erect or spreading, hardly reaching to the lowest flower-stalk in small specimens, and not much longer in tall plants. Flowers usually 2 or 3, but sometimes more; grey-blue with dark purplish-brown veins and markings. Dorsal sepal about 12 mm. long, broad and usually but not invariably blunt, very strongly veined—as are the petals and labellum—on the back. Lateral sepals greenish, not extending far below the labellum, and not crossed. Petals spreading or almost recurved, on very dark petioles. Labellum longer than the dorsal sepal; mid-lobe spathulate, strongly but often incompletely veined longitudinally; lateral lobes prominent but not large, veined, with crenulate margins. Column short and thick, the wings appressed; anther pointed.

Barrington Tops, N.S.W. (at about 5,000 feet), in bogs and wet places (J. L. Boorman, Jan., 1915, Miss. B. Sivyer, Jan. and Dec., 1925, L. Harrison, Jan., 1925, C. Barrett, Jan., 1926).

Mr. Boorman's and Professor Harrison's specimens are in the National Herbarium, Sydney; Miss Sivyer's and Mr. Barrett's are in my possession. By the courtesy of Professor Harrison and the authorities of the National Herbarium I was able to compare the former with the latter, and to satisfy myself of their identity. To Mr. Boorman belongs the credit of introducing this plant to botanical circles. It was regarded as possibly identical with *D. spathulata* Fitzg., which it resembles somewhat in colour and in the contour of the mid-lobe of the labellum. It appeared rather unlikely, however, that an orchid growing in bogs at an altitude of 5,000 feet on an eastern spur of the Dividing Range, should be identical with one of which the type locality is Forbes, on the dry western plains. I have not been able to examine an actual specimen of *D. spathulata*, but there can be little doubt that the Barrington Tops plant is quite distinct from that described and figured by Fitzgerald as *D. spathulata* (Australian Orchids, Vol. ii, Part 4). In this opinion I am supported by Dr. R. S. Rogers and Mr. Edwin Cheel. Besides minor differences, the following points may be mentioned: (1) *D. spathulata* exhibits no such striking venation on the flower-segments as that from which I have named the Barrington plant. (2) In *D. spathulata* the mid-lobe of the labellum is marked, almost horizontally, by what Fitzgerald calls "divergent glands or ridges"; in *D. venosa* it is merely veined longitudinally, the veins sometimes being interrupted. (3) The lateral lobes of the labellum in *D. venosa* are more prominent, with veins and crenulate margins. (4) The columns in the two plants are very distinct, that of *D. venosa* being short and thick, suggesting affinities with *D. bracteata* Fitzg. or *D. sulphurea* R. Br.

NOTES ON THE NATIVE FLORA OF NEW SOUTH WALES.

PART xi. MOREE TO MUNGINDI AND MOONIE RIVER—WITH A DESCRIPTION OF A NEW SPECIES OF EUCALYPTUS.

By R. H. CAMBAGE, C.B.E., F.L.S.

(Plates xviii-xxii and Map.)

(Continued from These PROCEEDINGS, *1918, p. 711.)*

[Read 28th July, 1926.]

The notes for this paper were obtained during a hurried visit to the locality in September, 1922, and, as the spring was dry, the growth of grasses and herbaceous plants had been much retarded, consequently only the more conspicuous members of the local flora were observed.

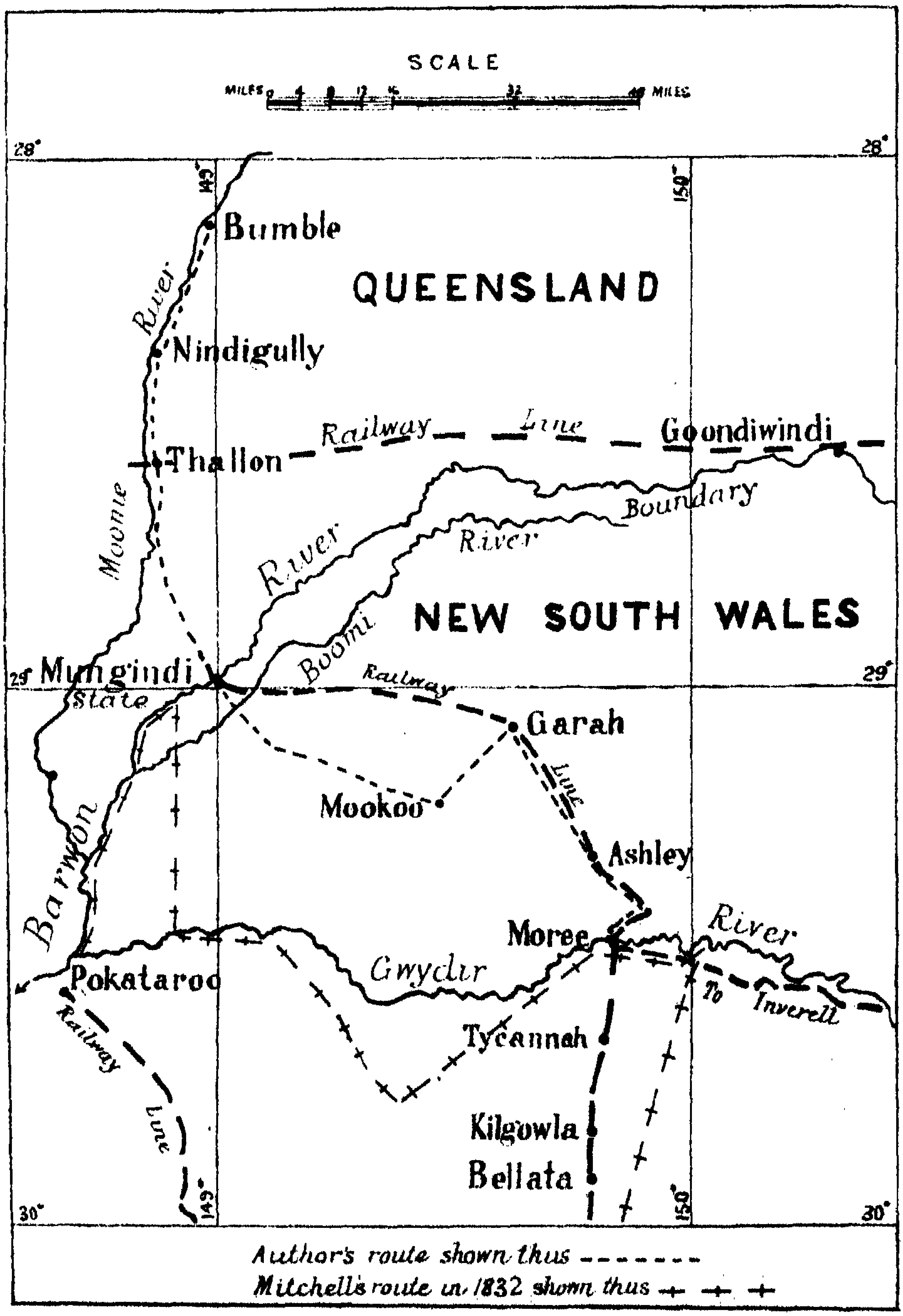
The route followed was from Moree to Garah, thence south-westerly to Mookoo, north-westerly to Mungindi, and northerly for nearly 70 miles through Thallon and Nindigully to Bumble Holding in Queensland. The flora of this area is typical of the central to western portion of the interior of New South Wales. It is so far west, and the atmospheric conditions so dry, that not a single species of those two large and widely distributed genera, *Acacia* and *Eucalyptus*, found there is also known in moister and colder Tasmania. On the other hand, owing to the fertility of the soil, the fairly good rainfall, and the absence of stony ridges, the vegetation is much more luxuriant than towards the centre of Australia or even at Broken Hill, where the rainfall is under ten inches annually.

Early Exploration.

The first explorer to visit this locality was Major (afterwards Sir) Thomas L. Mitchell, Surveyor-General, who, after following down the Namoi River nearly to Narrabri in January, 1832, proceeded a little to the eastward of the present railway line, and reached the Gwydir River about ten miles above Moree. The Gwydir was discovered in its upper portion in May, 1827, by Allan Cunningham, and named after the Right Hon. Lord Gwydir, but its native name in the Moree district appears to have been the Mehi, or Meei, and Mitchell refers to it as the "Big River", as well as the Gwydir. This stream he followed down, keeping some distance away from it on the southern side, until within less than twenty miles of its junction with the Barwon River, when he turned northerly, and, on January 23, 1832, reached the Barwon, called by the natives the Karaula, at about half a dozen miles below the modern town of Mungindi.

After crossing a large stream, probably the Boomi, before reaching the Barwon, Mitchell wrote:—

"Beyond this river channel, the wood consisted chiefly of casuarina; we next penetrated through two scrubs of dwarf eucalypti, and some trees of the callitris


SCALE
MILES 0 4 8 12 16 32 48 MILES
28°
149°
150°
Bumble
QUEENSLAND
River
Nindigully
Railway Line
Goondiwindi
Thallon
Moonie
Boundary
River
River
NEW SOUTH WALES
Boomi
29°
Mungindi
State
Railway
Garah
Line
Mookoo
Ashley
Barwon
Moree
River
Gwydir
Pokataroo
To Inverell
Railway
Tycannah
Line
Kilgowla
Bellata
30°
Author's route shown thus - - - - - - -
Mitchell's route in 1832 shown thus -+- -+- -+-

were also seen. At six miles, the woods assumed a grander character; masses of casuarinae enclosed open spaces covered with rich grass, which, being in some directions extensive, afforded park-like vistas, which had a fine effect, from the rich combination of verdure and shade, in a season of excessive heat. In one of these grassy alleys, a large kangaroo was seen, the first since we left the upper part of the Gwydir. The absence of this animal from the plains and low-grounds was remarkable, and we had reason to conclude that he seldom frequents those parts. At eight miles, our course was crossed by a deep and rapid river, the largest that we had yet seen. I had approached within a few yards of the brink, and was not aware of a river being near, until I saw the opposite water-worn shore, and the living waters hurrying along to the westward". (Mitchell's Eastern Australia, Vol. i, p. 94).

Mitchell next followed the Karaula or Barwon down to its junction with the Gwydir, and on his return, with a view to crossing and exploring farther north, he learnt that a small party of his expedition which had been following up with provisions, had met with disaster, two of their number, the blacksmith, Stephen Bombelli, and a bullock-driver, having been murdered by the natives, and the provisions destroyed, at a spot situated approximately seven or eight miles easterly from the present Kilgowla railway station. He then decided to retrace his steps to Sydney.

When Mitchell was nearing this river at its junction with the Macquarie between Walgett and Brewarrina in February, 1846, he wrote: "We had reached the united channel of the Macquarie and Morissett's Ponds, and were at an easy day's journey only distant from the junction with the Barwan or 'Darling'. The use of the aboriginal name of this river is indispensable amongst the squatters along its banks, who do not appear to know it to be the 'Darling'." (Tropical Australia, p. 71). A few days later (p. 75) he wrote: "Fifteen years before, I visited this river at a higher point where it was called the Karaula", and adds in a footnote: "We then understood the natives very imperfectly and might have been wrong about the name, which is the more likely, as *carawy*, which the name resembles, means any deep water-hole".

When returning from Queensland in December, 1846, Mitchell crossed the Barwon above Mungindi, and in about 5½ miles came to a stream called the Maal, which appears to be identical with the Boomi River (p. 396).

The *Casuarina* to which Mitchell so often refers after reaching the Gwydir is the Belah (*C. Cambagei*). Other plants referred to by him are: *Acacia pendula*, *Callitris* (*C. robusta*), *Stenochilus* (*Eremophila*) *maculatus*, *Eucalyptus* which he called Blue Gum (*E. rostrata*), "scrubs of dwarf eucalypti" just before reaching the Barwon (*E. microtheca*). He mentions "one tree of an uncommon genus" (p. 61), east of the Namoi, which was afterwards named *Capparis Mitchelli* Lindl. He also gives a drawing of leaves and fruit of *Owenia acidula* (Gruie). Having returned to the Gwydir from the Karaula he wrote (p. 115): "In thus returning I gathered for my kind friend Mr. Brown a hortus siccus, of such plants as appeared new to me; the field of research being obviously at this time confined to our line of route". The Mr. Brown referred to was probably Robert Brown, the eminent botanist, who at that time was Keeper of Botany at the British Museum, and who was in Australia in 1802-5.

Topography and Geological Formation.

The whole area dealt with in this paper is practically level, with very little rock showing, and for the most part fairly well covered with trees and shrubs, though there are a few small open plains.

The district averages nearly 600 feet above sea-level, various altitudes being: Moree 686 feet, Garah 593 feet, Mungindi 528 feet, and Thallon 570 feet.

The geological formation is known as the Rolling Downs Series of Cretaceous age for the most part, with Recent alluvium extending back from the water-courses. A partial analysis, omitting the water content, of a sample of soil from Mookoo, near Garah, by Mr. J. C. H. Mingaye, F.I.C., F.C.S., of the Department of Mines. gave the following result:—

Silica	60·62
Alumina	13·33
Ferric oxide	4·90
Lime	2·86
Magnesia	1·26
Potash	2·03
Soda	1·60
Phosphoric acid	0·13
Titanium dioxide	0·85
Ferrous oxide	0·20

At certain places, such as near the Boomi River south of Mungindi, and along the Moonie River at various points in Queensland, there are considerable areas of sand, probably old river deposits, and the difference in the vegetation of these sand "islands" and that of the prevailing soil throughout the district is most pronounced. As soon as these sand areas were reached it was noticed that the plants growing on them did not occur at all on the adjoining more basic soil, though they are not always restricted to these very highly siliceous soils.

These sand-loving plants are *Acacia leptopetala* (Gundabloui), *A. excelsa* (Ironwood, 30 to 40 feet high), *Santalum lanceolatum, Petalostigma quadriloculare* (Quinine), *Callitris robusta* (White or Cypress Pine), *Urtica incisa* (Nettle), *Eucalyptus tessellaris* (Carbeen or Moreton Bay Ash), and *E. terminalis* (Bloodwood. Plate xx, fig. 8).

When Sir Thomas Mitchell was building a boat on the Barwon, and was referring to the planking, he wrote: "For this part of the work we used blue gum (eucalyptus), the only callitris we knew of being some miles back along the route". No doubt the *Callitris* had been noticed by him growing on one of these sandy areas, probably near the Boomi River.

A note made by Mitchell when in Queensland on the 4th October, 1846, reads: "This day we again saw the Callitris; a tree so characteristic of sandy soils, but of which we had not observed a single specimen in the extensive country beyond".

The prickly pear (*Opuntia* sp.), is also quite at home on this sandy soil (Pl. xx, fig. 8), and, unfortunately, on the more basic soils as well, and for very many miles around Thallon and Nindigully has practically taken possession.

One of these sandy areas on the left bank of the Moonie River, a few miles north of Thallon, is known as "Mitchell's Sandridge", and is evidently that on which Mitchell was encamped while flood-bound from the 21st November to the 8th December, 1846.

Climate and Rainfall.

I am indebted to Mr. D. J. Mares, Meteorological Bureau, Sydney, for the following information:—

Element Station.	Average Wettest Month.		Wettest Month on Record.		Average Driest Month.		Average Annual Rainfall.		Temperature (Annual).	
	Amount.	Month.	Amount.	Month and Year.	Amount.	Month.	Amount.	No. of Years' Record.	Mean Maximum.	Mean Minimum.
Mungindi	272	Feb.	1,113	Feb. 1888	109	Aug.	2,016	38	80·8	54·8
Moree	272	Feb.	1,816	Mar. 1894	136	Aug.	2,339	45	82·1	52·8
Garah	302	Dec.	1,123	Jan., 1910	111	Sept.	2,239	18	Not equipped with thermometers.	
Goondiwindi* ..	323	Jan.	1,169	Mar. 1890	137	Aug.	2,557	34	Figures not available.	

* To end 1912 only.

List of Plants.

The following is a list of plants noticed by the roadside between Moree, Mungindi and Bumble, by far the greater number being seen before the Queensland border was reached.*

Marsileaceae: *Marsilea Drummondii* A. Br. (occurring in damp places, and known as Nardoo).

Pinaceae: *Callitris robusta* R. Br. (White or Cypress Pine, seen chiefly on the sandy areas).

Typhaceae: *Typha angustifolia* L. (Bullrush, growing in a drain flowing from an artesian bore).

Liliaceae: *Bulbine bulbosa* Haw.; *Thysanotus tuberosus* R. Br. (Fringed Violet) (Mitchell); *Tricoryne elatior* R. Br. (Mitchell).

Amaryllidaceae: *Crinum flaccidum* Herb. (Plains Lily).

Casuarineae: *Casuarina Cambagei* R. T. Baker (Belah, regarded by Mr. J. H. Maiden as *C. lepidophloia*), *C. Luehmanni* R. T. Baker (Bull Oak).

Urticaceae: *Urtica incisa* Poir. (Nettle, seen only on the sandy areas).

Proteaceae: *Grevillea striata* R. Br. (Beefwood, aboriginal name Muppoo, noticed near Ashley and to the north of Mungindi, and it occurs at least as far south as Cobar, Plate xix, fig. 3); *Hakea vittata* R. Br. (Needlewood, ten feet high), *H. leucoptera* R. Br. (Mitchell).

Santalaceae: *Exocarpus aphylla* R. Br. (Cherry, local aboriginal name Mirree): *Santalum lanceolatum* R. Br. (Noticed only on the sandy area).

Loranthaceae: *Loranthus Exocarpi* Behr. (Mistletoe, with *Acacia Oswaldi* as host), *L. Cambagei* Blakely (with *Casuarina Cambagei* as host), *L. Miquelii* Lehm. (with *Eucalyptus microtheca* as host), *L. Maideni* Blakely (with *Acacia homalophylla* as host, nearly ten miles north of Mungindi).

Polygonaceae: *Muehlenbeckia Cunninghamii* F.v.M. (Lignum).

* Plants recorded by Mitchell in 1846 and not noticed by me are marked (Mitchell).

Chenopodiaceae: *Rhagodia nutans* R. Br. (a Saltbush); *Bassia quinquecuspis* F.v.M. (Roly-poly, Plate xxi, fig. 9); *Enchylaena tomentosa* R. Br. (sometimes called Berry Saltbush).

Nyctaginaceae: *Boerhaavia diffusa* L. (Tarvine).

Capparidaceae: *Capparis lasiantha* R. Br. (aboriginal name Ngipan), *C. Mitchelli* Lindl. (Wild Orange, local aboriginal name Bumble, Moguile on the Bogan); *Apophyllum anomalum* F.v.M. (Currant Bush, aboriginal name Coobycullа).

Pittosporaceae: *Pittosporum phyllyraeoides* DC.

Leguminosae: Subfamily Mimosoideae—*Acacia salicina* Lindl. (Native Willow, local aboriginal name Carway, known as Cooba on the Lachlan, beautiful large pendulous shapely trees), *A. leptopetala* Benth. (aboriginal name Gundabloui), *A. homalophylla* A. Cunn. (Yarran, local aboriginal name Burrgie, noticed only to the north of Mungindi), *A. pendula* A. Cunn. (Myall), *A. Oswaldi* F.v.M. (local aboriginal name Midgit), *A. stenophylla* A. Cunn. (local aboriginal name Goodlay, Eumung on the Macquarie, sometimes known as River Cooba on the Lachlan), *A. harpophylla* F.v.M. (Brigalow), *A. excelsa* Benth. (Ironwood, seen chiefly on the sandy areas), *A. aneura* F.v.M. (Mulga, north of Mungindi), *A. spectabilis* A. Cunn. (Mitchell), *A.* sp. (aff. *mollissima*, but quite distinct), *A. Farnesiana* Willd. (locally called Briar-bush and Prickly Wattle); *Neptunia gracilis* Benth.

Subfamily Caesalpinioideae—*Cassia circinata* Benth. (5 to 6 feet high), *C. eremophila* A. Cunn., also var. *zygophylla* Benth.

Subfamily Papilionatae—*Swainsona procumbens* F.v.M. (Mitchell), *S. tephrotricha* F.v.M.; *Vigna lanceolata* Benth. (Mitchell).

Geraniaceae: *Erodium cygnorum* Nees (Pelican's Beaks).

Rutaceae: Subfamily Rutoideae—*Geijera parviflora* Lindl. (Wilga, aboriginal name Mullera, a handsome shade tree).

Subfamily Flindersioideae—*Flindersia maculosa* F.v.M. (Leopard-wood, so called because of its spotted bark, aboriginal name Bukkulla).

Subfamily Aurantioideae—*Atalantia glauca* Hook f. (Native Lime).

Meliaceae: *Owenia acidula* F.v.M. (Gruie, Colane or Emu Apple, very shapely trees).

Euphorbiaceae: *Petalostigma quadriloculare* F.v.M. (known as Quinine in North Queensland); *Euphorbia Drummondii* Boiss. (a small recumbent plant often regarded as poisonous to stock); *Byeria viscosa* Miq. (Mitchell).

Celastraceae: *Celastrus Cunninghamii* F.v.M. (Mitchell).

Sapindaceae: *Atalaya hemiglauca* F.v.M. (Whitewood, local aboriginal name Birrah); *Heterodendron oleaefolium* Desf. (Western Rosewood, aboriginal names Boonery and Boonbutt); *Dodonaea viscosa* Jacq. var. *Spathulata* Benth. (Hopbush).

Rhamnaceae: *Ventilago viminalis* Hook. (Supple Jack, up to 20 and 25 feet high).

Malvaceae: *Malvastrum spicatum* A. Gray (Mitchell); *Hibiscus Sturtii* Hook.

Sterculiaceae: *Brachychiton populneus* R. Br. (*Sterculia diversifolia* G. Don, Kurrajong).

Thymeleaceae: *Pimelea microcephala* R. Br.

Myrtaceae: *Angophora melanoxylon* R. T. Baker (Apple Tree); *Eucalyptus melanophloia* F.v.M. (Silver-leaved Ironbark), *E. populifolia* Hook. (Bimble or Shiny-leaved Box, growing on the basic soil), *E. bicolor* A. Cunn. (aboriginal name Cooboroo, a box tree), *E. microtheca* F.v.M. (Coolabah), *E. rostrata* Schlecht. (River Red Gum, growing along the banks of the streams), *E. dealbata* A. Cunn.

(a Red Gum), *E. tessellaris* F.v.M. (Carbeen or Moreton Bay Ash), *E. terminalis* F.v.M. (Bloodwood, on the sandy areas, Plate xviii, fig. 1), *E. Bucknelli*, n. sp.; *Melaleuca trichostachya* Lindl. (Teatree, on the banks of the Boomi and Barwon Rivers).

Halorrhagaceae: *Myriophyllum verrucosum* Lindl. (a small aquatic plant).

Umbelliferae: *Didiscus Benthami* Domin (Mitchell).

Oleaceae: *Jasminum lineare* R. Br. (Jasmine, a woody twining plant).

Apocynaceae: *Carissa ovata* R. Br. (Mitchell); *Alstonia constricta* F.v.M. (Quinine or Peruvian Bark, aboriginal name Cuddymundo); *Lyonsia eucalyptifolia* F.v.M. (a woody climber, scrambling over trees sometimes to a height of forty feet. Plate xix, fig. 4).

Convolvulaceae: *Polymeria longifolia* Lindl. (Mitchell).

Verbenaceae: *Verbena officinalis* L. (Vervain).

Scrophulariaceae: *Mimulus gracilis* R. Br. (little blue flowers growing in masses); *Morgania glabra* R. Br. (Mitchell).

Myoporaceae: *Myoporum acuminatum* R. Br., *Eremophila Mitchelli* Benth. (sometimes called Sandalwood, aboriginal name on the Bogan Butha or Budtha, Plate xix, fig. 5), *E. longifolia* F.v.M., *E. bignoniflora* F.v.M. (Eurah), *E. maculata* F.v.M. (Native Fuchsia).

Rubiaceae: *Canthium oleifolium* Hook. (locally called Myrtle).

Cucurbitaceae: *Cucumis trigonus* Roxb.

Campanulaceae: *Wahlenbergia gracilis* A. DC. (Bluebells).

Goodeniaceae: *Goodenia glauca* F.v.M. var. *sericea* Benth.

Compositae: *Craspedia globosa* Benth., *Podolepis longipedata* A. Cunn., *Leptorrhynchos panaetioides* Benth., *Helichrysum apiculatum* DC., *Helipterum anthemoides* DC. (sometimes in masses of an acre or more. Plate xx, fig. 6), *H. polyphyllum* F.v.M., *Senecio lautus* Soland.

General Remarks on Various Species.

The trees known as Belah, which are referred to above as *Casuarina Cambagei*, are widely distributed in central New South Wales, extending into Queensland at least as far north as the Emerald district, and are associated with gilgai country which is usually damp for a great portion of the year. The trees are often upwards of sixty feet high and the timber is remarkably hard, being one of the best in Australia for shaft bearings. For many years this species was placed under *C. glauca* Sieb., the Swamp Oak of the coast, which grows near salt water or in saline soil, but has never been found in the interior of this State.

In 1877, Baron von Mueller described a species (*Fragm.*, x, 115), under the name of *C. lepidophloia*, and stated that it grew "In deserts between the Bogan, Darling, and Lachlan Rivers, together with *C. glauca* (L. Morton). Near the Murray River, in low sandy places. Small or middle-sized trees". . . "Cones. Shorter than an inch, depressed globular, the valve-like bracteoles somewhat turgid, slightly carinate towards the apex".

When describing *C. Cambagei* Mr. Baker (These Proc., xxiv, 1899, 605) pointed out differences between it and *C. lepidophloia* as described, and regarded the two species as distinct.

Mr. J. H. Maiden in 1904 (*Forest Flora of New South Wales*, Part xiii, 1904, 79) wrote as follows: "On Mr. Baker's description of the Belah as *C. Cambagei*, in 1900, I accepted the name, and distributed the plant under that name for over

two years, when circumstances led me to re-examine the plant, and I found that my earlier determination of *C. lepidophloia* was correct".

During subsequent years attention has been given to a species of *Casuarina*, also identified as *C. lepidophloia*, found in the western portion of New South Wales and extending past Broken Hill across portion of South Australia at least as far as Iron Knob, west of Spencer's Gulf, and the question has been raised as to whether Mueller may not have included both this form or species, as well as the Belah, under *C. lepidophloia*. The two trees have close affinities, their timber being similar, neither showing the medullary rays as do all the other Casuarinas, but while *C. Cambagei* selects the damp depressions, the other, a smaller tree, grows in sandy areas and on the elevated land, and at Iron Knob is flourishing on the sides of this eminence practically to the summit which reaches 600 feet above the surrounding plain, a situation in which it seems scarcely conceivable the Belah would grow. The trees on Iron Knob and eastwards on the sandy areas towards Spencer's Gulf reach a height ranging from 12 to 20 feet.

Cones collected at Iron Knob in April, 1921, slightly resemble those of the Belah, but the latter, when the seeds are shed, are much more open, the valves being longer, while the Iron Knob cones are neater and more compact, the valves being distinctly carinate or keeled towards the apex, a feature which Mueller mentions applied to *C. lepidophloia*. The branchlets of the latter are much thicker than those of the Belah.

In Plate 51 of the Forest Flora (*supra*), Mr. Maiden has figured a specimen, "C", which came from north-western Victoria, near Mildura, but this does not appear to be Belah, but resembles the form or species with thicker branchlets which extends across to Iron Knob, while the fruit marked "K" on the same Plate is typical Belah.

The specimen which Mueller referred to as coming from "near the Murray River", was recently seen in the National Herbarium, Melbourne, and while it is placed with other type specimens of *C. lepidophloia* from the Bogan and Lachlan Rivers, it bears the following label: "*C. glauca* Sieb. N.W. desert of Victoria, Mr. Morton. Remarkable for the close texture of its wood". The label is in the handwriting of Baron von Mueller. Other type specimens from the Bogan are also labelled *C. glauca*, which apparently shows that Mueller had so identified them before naming them *C. lepidophloia*, and then neglected to alter the labels. The cones of the specimen from the N.W. desert of Victoria are rather more elongated than those of typical Belah, and the valves perhaps not quite so long, but are much broken or damaged; still they appear to be nearer to those of *C. Cambagei* than to those from Iron Knob, near Spencer's Gulf, and it seems that further investigation will probably uphold Mr. Maiden's contention that *C. lepidophloia* and *C. Cambagei* are conspecific. There is no doubt, however, that the trees at Mungindi belong to the species named *C. Cambagei* by Mr. Baker.

Casuarina Luehmanni (Bull Oak) is not plentiful in the Mungindi district, its home being rather more to the eastward, off the plains, but it occurs upwards of fifteen miles north of Mungindi, and again at Nindigully on the edge of the sandy area. This species has a range in Eastern Australia from the south-west corner of Victoria to Biboohra, west of Cairns in North Queensland.

Casuarina Cunninghamiana (River Oak) was not noticed on any of the rivers in this district, but it occurs on the upper waters of both the Gwydir and the Barwon.

Capparis lasiantha (Ngipan) is a climber with hooked stipular prickles, and may climb over a tree to a height of 20 to 30 feet. It has an edible jelly-like fruit which is very highly regarded by some people.

Acacia leptopetala (Gundablouі), was found only on the highly siliceous soil, and is a bushy wattle reaching a height of 20 to 25 feet, sometimes with a stem diameter of 10 inches to 1 foot. Its flowers evidently contain honey, for a clump of these trees, which were in full flower on the 21st September, were covered with bees. This species is recorded as occurring on the Murchison River, Western Australia, and, no doubt, crosses the continent by selecting the sandy soils. It was seen near the Boomi River, south of Mungindi, and at several points along the Moonie River in Queensland, including Nindigully and Bumble. It was previously known to occur near Nyngan in this State. This species affords a splendid example of the fact that certain trees select particular geological formation.

Acacia aneura (Mulga) was noticed at about 20 miles north of Mungindi growing on reddish soil among ironstone pebbles, and at Bumble, but these localities are near the eastern margin of the habitat of this species which extends away towards the centre of Australia. Mitchell referred to the species as Malga. From Broken Hill right across to Western Australia there are several allied species of *Acacia* which are designated Mulga.

Acacia Cambagei (Gidgea or Gidgee) was not seen over the area traversed, the locality being too far east for this species, though it occurs about twenty miles to the westward. It extends from the Darling River country south of Bourke to within about 80 miles south of the Gulf of Carpentaria, and also goes for a considerable distance into South Australia.

Flindersia maculosa (Leopard-wood) passes through a remarkable stage in its early growth. It is first a spreading plant with numerous branches, but later one definite shoot outstrips the rest, and develops into the future bole of the tree, while all the others fall off, leaving the tree with a clean trunk (Plate xxi, fig. 10).

Petalostigma quadriloculare was noticed on the highly siliceous soils only, and grows to a height of over 30 feet (Plate xxi, fig. 11). In northern Queensland it is known as Quinine from the exceedingly bitter taste of its numerous small yellow fruits. Leichhardt refers to this tree throughout his journey in 1844-45 across northern Australia, and calls it the "Severn Tree", after the Severn River, a tributary of the Upper Barwon, in northern New South Wales, where he first saw it. When near the Norman River at the Gulf of Carpentaria he wrote: "The emu here feeds on the fruit of the little Severn tree, which is so excessively bitter, as to impart its quality to the meat, and even to the gizzard and the very marrow" (Journal of an Overland Expedition in Australia from Moreton Bay to Port Essington, p. 385).

Angophora melanoxylon (Apple) was seen only at Bumble, about 70 miles north of Mungindi. The trees, which were up to about 40 and 50 feet high, with a diameter of about 15 inches, were growing on reddish sandy soil. The timber when freshly cut was found to be very dark in colour. This species is well known at Coolabah, in New South Wales, which is the type locality (Plate xx, fig. 7).

Eucalyptus bicolor (Cooboroo) is a narrow, pendulous-leaved box tree with fairly rough bark to the branchlets. It grows on flats often adjacent to water-courses throughout the whole of western New South Wales. Mitchell (Eastern Australia, Vol. ii, p. 80) refers to this tree as occurring on the banks of the

Lachlan, and gives the native name as Goborro, a name very similar to that of the natives of the upper Darling. It was seen to the north of Mungindi. Mitchell also identified it near the Moonie River in 1846.

Eucalyptus microtheca (Coolabah) is a common tree in the district, and has box bark on the trunk and lower branches, similar to trees of this species growing at Longreach, in Central Queensland. At Bourke the whole of the branches and the upper portions of the trunks are smooth and white, while on the Lower Flinders, towards the Gulf of Carpentaria, the box bark extends to the branchlets. This shows a gradation in the amount of smooth bark which appears on these trees, the quantity decreasing from south to north. The fruits, with their very exserted valves, remain practically the same throughout.

Eucalyptus rostrata var. *acuminata* was noticed near Mitchell's Sandridge, a few miles north of Thallon, and this is probably the exact spot where Mitchell collected it in 1846. The buds are more conical and less rostrate than in typical *E. rostrata*, which, however, is growing on the Barwon at Mungindi.

Eucalyptus tessellaris (Carbeen or Moreton Bay Ash) was found on the siliceous soils only, and this is not remarkable seeing that it has a close affinity to the Bloodwood group, which all avoid the basic soils. Of the Eucalypts in this district, the leaves of this species are regarded as the best as fodder for stock. It is easily identified in the forest from its rough scaly bark at the base which ends abruptly, above which the bark is smooth and white, but there is no gradual toning off from one to the other as in many species (Plate xx, fig. 8).

Eucalyptus terminalis (Bloodwood) was not found off the siliceous soils, and this species in northern Queensland seems to favour the flat land in preference to the ridges. Some of the trees were decidedly large in comparison with forest trees in the locality, one on Mitchell's Sandridge measuring a height of about 90 feet, with a bole 4 feet in diameter (Plate xviii, fig. 1).

Melaleuca trichostachya (Teatree) is growing along the banks of the Boomi and Barwon Rivers in some cases with a stem diameter of from 3 to 4 feet at a few feet from the ground. Some trees produce a mass of aerial roots suspended, from one side of the tree, for perhaps 6 feet near the base. They are probably induced to grow into the water while it is high during the rainy season, but as it recedes this gigantic fringe or ramee remains suspended in the air.

Canthium oleifolium has a wide distribution in the western districts, being common around Cobar and Nymagee, while it extends a considerable distance into Queensland. Around Garah it is known as Myrtle, but south of the Bogan it is commonly called Wild Lemon, from a similarity in the colour of the leaves, and, to some extent, the general appearance of the tree, though the fruits are totally different (Plate xviii, fig. 2).

Comparison with Tasmania.

As an evidence of the dominating influence of climate upon plant distribution it may be mentioned that, on the Nandewar Mountains, situated about 120 miles south-easterly from Mungindi, at altitudes varying from 3,000-5,000 feet above sea-level, about 60% of the plants found there occur also in Tasmania, there being considerable similarity in the climatic conditions. At Boggabri, about 140 miles south by east from Mungindi, with a warmer climate than the Nandewars and an elevation of 800-1,200 feet, about 36% of the plants are found in Tasmania. Around Mungindi, with a still lower elevation and slightly warmer climate, out of

one hundred species noticed, only fourteen or 14% are recorded by Mr. L. Rodway for Tasmania.

The plants common to Mungindi and Tasmania are: *Typha angustifolia*, *Bulbine bulbosa*, *Tricoryne elatior*, *Urtica incisa*, *Rhagodia nutans*, *Euphorbia Drummondii*, *Beyeria viscosa*, *Dodonaea viscosa*, *Didiscus Benthami*, *Verbena officinalis*, *Wahlenbergia gracilis*, *Helichrysum apiculatum*, *Helipterum anthemoides* and *Senecio lautus*.

I wish to thank Mr. A. W. Bucknell, of Mookoo, for supplying me with the local aboriginal names of a number of plants, and for facilitating the collecting of specimens. I am also indebted to the late Mr. J. H. Maiden, I.S.O., F.R.S., Mr. E. Cheel and Mr. W. F. Blakely, all of the Botanic Gardens, for assistance and corroboration in the identification of some of the plants.

EUCALYPTUS BUCKNELLI, n. sp. Plate xxii.

Folia matura, lanceolata, longa circa 6-15 cm. lata 1-3 cm. cum punctis rectis aut uncis, viridia prope cinerea, interdum glauca in utramque partem, glabra, costa media distincta, venae laterales aliquanto prominentes, dispositae ex costa media cum angulo circa 45-55 graduum, cum venularum tenuiorum reticulo interveniente, vena intra marginem aliquanto procul margine, glandulae olei parvae sed multae, petiolus longus 2 mm. ad 1 cm.

Gemmae, clavatae, in breve pedicellatae, acutae, leviter glaucae, calycis tubus aliquanto campanulatus longus 3-4 mm., staminis annulus parvus sed distinctus, directus, operculum in coni formâ longum 2-3 mm.

Fructûs, in piri aut ovi formâ, truncati, longi 4-5 mm., diametros 3-6 mm. valvae fere exsertae, pedunculi longi 5 mm. ad 1·4 cm.

A tree about 40 feet high, with stem-diameter of 18 inches to 2 feet.

Branchlets terete, brown to glaucous.

Mature leaves lanceolate, from about 6 to 15 cm. long, 1-3 cm. broad, with straight or hooked points, greyish-green to sometimes glaucous on both sides, glabrous, midrib distinct, lateral veins fairly prominent, arranged at an angle of from about 45 to 55 degrees with the midrib, with a network of finer veinlets between, intramarginal vein fairly distant from the edge, oil glands small but numerous, petiole 2 mm. to 1 cm. long.

Buds clavate, shortly pedicellate, acute, slightly glaucous, calyx tube somewhat campanulate 3-4 mm. long, staminal ring small but distinct, vertical, operculum conical, 2-3 mm. long.

Flowers pedicellate, umbels chiefly in terminal panicles, with three to seven flowers, anthers semi-terminal, broad, somewhat like those of *E. crebra*, gland at back, filament nearly at the base.

Fruits pyriform to ovoid, truncate, 4-5 mm. long, 3-6 mm. in diameter, valves usually exserted, peduncles 5 mm. to 1·4 cm. long.

Bark shortly fibrous to slightly furrowed.

Timber reddish-brown, very hard, heavy and interlocked.

Habitat.—About 20 miles north of Mungindi (type), Mookoo, and at Bumble in Queensland. About 15 miles south-east of Moree (Forest Guard, W. M. Brennan).

This species is named in honour of Adrian Wentworth Bucknell, Licensed Surveyor, of Mookoo, who is much interested in the local plants, and has supplied many native names.

Affinities.—Its closest affinity appears to be with *E. melanophloia* and *E. microtheca*, but it seems to be more closely associated with the former in the

forest, the two species often growing together, while *E. microtheca* may be a quarter of a mile away. *E. populifolia* and *E. bicolor* may be also growing near. Its bark on the trunk and branches may be described as being between that of a box tree and an ironbark, while the fruits somewhat resemble those of *E. microtheca*, although the valves of the latter are more exserted. In shape, the fruits are not unlike those of *E. melanophloia*, especially those from about 20 miles north of Mungindi (No. 4462).

The small fruited form of *E. Bucknelli* (No. 4389) from the south of Mungindi, somewhat resembles *E. populifolia* and *E. bicolor* so far as the fruits are concerned, but the leaves and venation are different.

From *E. Yagobiei* Maiden, it differs mainly in the shape of the fruits and to some extent in the bark. The fruits of *E. Yagobiei* have strongly exserted valves.

If it could be shown that this tree originated as a hybrid, then its parents would appear to be *E. melanophloia* and *E. microtheca*, but the trees are so numerous that it seems evident the species now reproduces itself, whatever may have been its origin. It is remarkable that where natural *Eucalyptus* hybrids are suspected, one of the supposed parents often belongs to the group of trees popularly known as Ironbark, while the other belongs to the Box group. (See "Natural Hybrids", by J. H. Maiden, Critical Revision of the Genus Eucalyptus, Part liii, 1922, 107.)

Seedlings (No. 4402 from Bumble). Plate xxii, fig. 1.

Hypocotyl terete, red, glabrous, 6 mm. to 1·5 cm. long.

Cotyledons obtusely oblong to slightly reniform, entire, 2 to 2·5 mm. long, 3 to 5·5 mm. broad, upperside green, underside pale green; petiole 2 to 3 mm., reddish near base.

Stem terete, red. First and second internodes 3 to 5 mm.; third 4 to 6 mm.

Seedling foliage opposite for at least four or five pairs, entire, glabrous, linear-lanceolate, upperside green, underside pale green, petiole 1 to 1.5 mm. First pair 5 to 8 mm. long, 1·5 to 2·5 mm. broad; second pair 9 mm. to 1·3 cm. long, 1·5 to 3 mm. broad; third pair 1 to 1·4 cm. long, 2 to 3 mm. broad.

EXPLANATION OF PLATES XVIII-XXII.

Plate xviii.

1. *Eucalyptus terminalis*. Bloodwood. Mitchell's Sandridge, Thallon.
2. *Canthium oleifolium*.

Plate xix.

3. *Grevillea striata*. Beefwood.
4. *Lyonsia eucalyptifolia*.
5. *Eremophila Mitchelli* in flower.

Plate xx.

6. *Helipterum anthemoides*.
7. *Angophora melanoxylon*. Bumble Station.
8. *Eucalyptus terminalis* on left; *Eucalyptus tessellaris* (Carbeen), two white trees.

Plate xxi.

9. Roly Poly (*Bassia quinquecuspis*).
10. *Flindersia maculosa*. Young plant on left; mature tree, formerly pollarded, on right.
11. *Petalostigma quadriloculare*.

Plate xxii.

Eucalyptus Bucknelli, n. sp.

1. Seedling from Bumble (No. 4402). 2. Buds from Moree. 3. Fruits and leaves from north of Mungindi (No. 4462). 4. Fruits from Bumble (No. 4402).

ON SOME AUSTRALIAN CURCULIONIDAE.

By ARTHUR M. LEA, F.E.S.

[Read 25th August, 1926.]

The species dealt with in the following pages are all of small size, but some of them are of great interest.

Erirhinides.

ENCOSMIA.

This genus is abundantly represented in Australia, although but four of its species have been named hitherto; as it has numerous allies I have passed over several species which might fairly be regarded as belonging to it, but which differ in certain details considered by Blackburn as of generic importance. The following species all agree in the characters noted in Blackburn's table of Erirhinides (*Trans. Roy. Soc. S. Aust.*, 1914, 148), but the male of *E. ventralis* (described elsewhere) has the apical segment of the abdomen slightly longer than the second; but as it is close to several others in which the abdomen is normal, it was not considered advisable to separate them generically. Other species also differ sexually in the length of the apical segment. In many respects the genus is extremely close to *Empolis*, the species of which are usually larger, but there appears to be no single character by which the species of the latter genus can be separated, other than by the longer apical segment of the abdomen.

Table of Species of Encosmia.

A. Elytra bifasciculate.
  - *a.* With golden spots on shoulders and below fascicles .... *cornuta*
  - *aa.* Without such spots .... *fasciculata*

AA. Elytra nonfasciculate.
  - B. Club at most feebly infuscated, scarcely if at all darker than scape.
    - *b.* Metasternum black or blackish.
      - *c.* Clothing entirely white.
        - *d.* Prothoracic and abdominal clothing dense and concealing derm .. *alba*
        - *dd.* Clothing there sparser, so that punctures readily traceable .... *melanostetha*
      - *cc.* Clothing not entirely white.
        - *e.* Second joint of funicle shorter than third and fourth combined .... *cryptoderma*
        - *ee.* Second as long as third and fourth combined.
          - *f.* A large subtriangular patch of dark scales on each elytron .... *adelaidae*
          - *ff.* Without triangular patches of scales .... *interrupta*
    - *bb.* Metasternum pale.
      - *g.* Scales conspicuously variegated on apical half of elytra ...... *ruficornis*
      - *gg.* Scales not conspicuously variegated there.
        - *h.* Elytral scales forming a white postmedian fascia followed by an apparently denuded one .... *albifascia*
        - *hh.* Elytral clothing nowhere forming a complete fascia.

i. Apical segment of abdomen of male longer than second .. *ventralis*
ii. Apical segment of both sexes shorter than second.
j. Size consistently more than 2·5 mm. .... *blackburni* (typical)
jj. Size consistently less than 2·5 mm.
k. Elytral clothing with many sudden interruptions .... *curvirostris*
kk. Elytral clothing almost uniform .... *blackburni* (variety)
BB. Club black or deeply infuscated.
C. Apical slope of elytra with variegated clothing.
l. Each side of prothorax with a narrow vitta of pale scales .... *bivittata*
ll. Sides widely clothed (sometimes irregularly so) with pale scales.
m. Elytra with a large semicircular patch of pale scales at base .... *basalis*
mm. Elytra without such a patch.
n. Pale prothoracic scales with a greenish gloss .... *variegata*
nn. Pale prothoracic scales not at all greenish.
o. Pale scales mostly glossy .... *fasciata*
oo. Pale scales opaque .... *pulicosa*
CC. Apical slope of elytra with scales not conspicuously variegated.
D. Suture black or deeply infuscated .... *suturalis*
DD. Suture not darker than adjacent parts.
E. Apical part of suture with conspicuous white scales.
p. Basal half of suture with similar scales .... *medioglabra*
pp. Basal half without such scales .... *apicalis*
EE. Suture without special scales.
F. Length about 3 mm. (usually slightly more) .... *montana*
FF. Length less than 3 mm.
G. Pale castaneous (club and eyes excepted) .... *nigriclava*
GG. Dark brown .... *minor*

Notes on Table.

B. When at all gummy the club is apt to appear darker than it really is, so it is necessary to examine it in a good light; in *E. variegata* and *E. pulicosa* it is less deeply infuscated than in the other species referred to BB, but it is distinctly darker than the scape. On some of the species placed here its extreme tip, from some directions, appears to be infuscated.

b. On some specimens of *E. adelaidae* it is hardly more than infuscated, but even on these it is darker than the abdomen. On most species its clothing is white or whitish.

f. On specimens in good condition, on partial abrasion the patch disappears or becomes inconspicuous.

i. A character that might be considered as excluding the species from *Encosmia*.

j. Excluding the rostrum.

E. infuscata (the type and only specimen known to Blackburn is now in the British Museum) was not identified amongst any of the species before me; in the table it evidently could be associated with the species of BB.

ENCOSMIA FASCIATA Lea.

This species is widely distributed and variable. There are before me specimens from New South Wales (Ryde, Galston and Blue Mountains), Victoria (Sea Lake), Tasmania (Hobart, Burnie and Nubeena), and South Australia (Murray Bridge). Scarcely any two specimens have identical markings, but they all have a large patch of pale scales on the apical slope of the elytra, the patch varying from a rather dingy white to somewhat golden, and enclosing a dark spot between the suture and the preapical callus on each elytron (much as on *E. adelaidae*, which species differs considerably in the rest of the elytral clothing); on the type, how-

ever, the spots are not enclosed externally; there are also patches of pale scales on the shoulders and on the sides of prothorax, and spots elsewhere; on several specimens there is a conspicuous (but usually interrupted) dark fascia before the pale part of the apical slope. The type is a male; the female differs in having the rostrum slightly longer, thinner, more curved, noncarinate, with smaller punctures and the clothing confined to the basal third, the antennae are inserted at a slightly greater distance from the apex of the rostrum, the abdomen is more convex, and the apical segment is slightly smaller.

ENCOSMIA ADELAIDAE Blackb.

There are in the South Australian Museum three specimens bearing Blackburn's labels as *E. adelaidae*; of these two are mounted on card labelled "*Encosmia adelaidae* Blackb. ♀ Type ♂ Cotype", the other is labelled "*Encosmia adelaidae* Blackb.". I believe these specimens belong to two species, and that Blackburn was deceived by the partial abrasion of some specimens causing a deceptive resemblance to nonabraded specimens of the other. The type male is in the British Museum; its clothing as noted in the original description puts beyond doubt the species meant. The single specimen on a card, and three others from Mount Lofty, agree with the original description; the pair on a card and some other specimens of the same species may be named as follows:—

ENCOSMIA BLACKBURNI, n. sp.

♂. Castaneous. Moderately clothed with stramineous scales, becoming white on under surface.

Rostrum rather long and curved, behind antennae with fine, partially concealed carinae, and rows of punctures; in front of them with small but sharply defined punctures. Prothorax moderately transverse, rather densely granulate-punctate, but derm partially concealed. Elytra parallel-sided to near apex; striate-punctate, punctures large, much wider than interstices, and scarcely obscured by clothing. Under surface with sharply defined punctures; two basal segments of abdomen shallowly depressed in middle, fifth slightly shorter than second. Length, 2·8-3 mm.

♀. Differs in having the rostrum slightly longer, thinner, more curved and without carinae or clothing (on the male the basal third is partly clothed), the abdomen larger and the two basal segments evenly convex.

Hab.—South Australia: Adelaide (Rev. T. Blackburn), Mount Lofty (J. G. O. Tepper); Victoria, Somerville (A. M. Lea).

The antennae and legs are paler than the body parts, but the differences are slight, the club is not even slightly infuscated. The scales on the elytral interstices are fairly dense but are thin, so that the rows of punctures are not concealed, each puncture has a scale or seta arising from it; the clothing appears to be easily abraded, but even on badly rubbed examples the punctures do not appear to be much wider than on specimens in perfect condition. The specimens from Adelaide were regarded by Blackburn as belonging to *E. adelaidae*, but they differ from that species in the scales being decidedly thinner (almost setae), not variegated, and forming a yellow cross and dark triangles, not almost or quite concealing the derm in parts, so that the punctures appear to be much smaller than they really are, the metasternum not infuscated, etc.

Seven specimens from South Australia (Mount Lofty, Tepper and Lucindale, B. A. Feuerheerdt) and Victoria (Diamond Creek, in March, A. Simson), probably represent a variety, they differ in being smaller (2-2·25 mm.), and the males have the club somewhat infuscated, although far from black.

ENCOSMIA FASCICULATA, n. sp.

♂. Dark brown, sterna and abdomen black, antennae reddish, club and part of funicle infuscated. Clothed with small scales, variegated on upper surface, white on under surface, except on sides of sterna; a small black fascicle on third interstice of each elytron, at summit of apical slope.

Rostrum about as long as prothorax, moderately curved, with rows of punctures, each containing a scale, alternated with fine carinae from base to insertion of antennae, in front of them with naked punctures only. Prothorax slightly shorter than the median width, but narrowed to base and more strongly so to apex; with crowded punctures in parts concealed by scales. Elytra distinctly wider than prothorax, parallel-sided to beyond the middle; striate-punctate, punctures large, each containing a scale. Under surface with dense, concealed punctures; two basal segments of abdomen flat but not concave in middle, the second slightly longer than fifth. Length, 3·5 mm.

Hab.—New South Wales: Sydney (Dr. E. W. Ferguson), unique.

A somewhat rusty looking species, with small elytral fascicles much as on most species of *Enlopea*, but with the prosternum and abdomen of *Encosmia*. The scales on the upper surface are mostly whitish and pale brown, irregularly intermixed, except that in the striae they are mostly whitish; on the pronotum, however, there is a distinct narrow median line of yellowish scales; the white scales on the under surface and legs, from some directions, have a faint golden gloss.

ENCOSMIA ALBA, n. sp.

♀. Pale castaneous, mesosternum and metasternum black or blackish. Clothed with white scales.

Rostrum distinctly longer than prothorax, thin and moderately curved; with crowded concealed punctures about base, but smaller and naked elsewhere. Antennae inserted exactly half-way between base and apex. Prothorax as long as the median width; with crowded concealed punctures. Elytra parallel-sided to near apex; striate-punctate, punctures large and wider than interstices. Under surface with crowded, concealed punctures; two basal segments of abdomen large and convex, the second almost twice the length of fifth. Length, 2·25 mm.

Hab.—Victoria: Sea Lake (J. C. Goudie's No. 629).

In general appearance strikingly like *Thechia pygmaea*, but that is a clawless species. The white scales are dense and cover the derm almost evenly, except that the seriate punctures on the elytra are exposed, hence the elytra appear to have alternating white and castaneous lines; the rostrum also is clothed only about the base.

ENCOSMIA MELANOSTETHA, n. sp.

♀. Pale castaneous; mesosternum, most of metasternum and middle parts of prosternum black or blackish. Moderately clothed with thin white scales.

Rostrum the length of prothorax, thin and moderately curved; with small, naked punctures. Prothorax slightly wider than long, with dense and rather large punctures, distinct through clothing. Elytra thin and parallel-sided to near apex; with regular rows of large, quadrate punctures, not concealed by scales. Under surface with well defined punctures; two basal segments of abdomen large and convex, the second distinctly longer than fifth. Length, 2-2·25 mm.

Hab.—Tasmania: Strahan in April (Aug. Simson).

Somewhat thinner than the preceding species, with a shorter rostrum and clothing nowhere dense enough to conceal the derm. The three specimens taken by Mr. Simson vary slightly in the extent of the black parts of the sterna.

ENCOSMIA CRYPTODERMA, n. sp.

Dark brown, elytra paler, under surface black, antennae castaneous. Densely clothed with variegated scales, becoming almost white on under surface of body and of legs.

Rostrum the length of prothorax, moderately curved; with numerous small but sharply defined punctures; but concealed towards base. Antennae shorter than usual in genus, second joint of funicle shorter than the two following combined. Prothorax fully as long as the median width; with crowded, concealed punctures. Elytra parallel-sided to near apex; striae partly concealed. Under surface with crowded, concealed punctures; two basal segments of abdomen large, slightly flattened in middle, the fifth distinctly shorter than second, and with a median depression. Legs shorter than usual, each claw joint exserted for about half its length. Length, 3 mm.

Hab.—Queensland: Cairns district (F. P. Dodd), unique.

A somewhat aberrant species. The first joint of the funicle is shorter than is usual in the genus, but is as long as the second to fourth combined, the second is also unusually short. The clothing is so dense that the derm is mostly concealed; whitish scales form a J on the left side of the prothorax (reversed on the right), a large irregular patch on the basal third of elytra, a small spot on each shoulder, and smaller spots elsewhere; the rest of the clothing on the upper surface is mostly of a more or less muddy-brown, but there are some obscurely blackish spots as well. The elytral striae appear to be only about one-third the width of the interstices, but on abrasion would probably appear much larger, in some lights their contained punctures have a castaneous gleam.

ENCOSMIA INTERRUPTA, n. sp.

♂. Castaneous; head (but not rostrum) and scutellum somewhat darker, under surface (apical segment of abdomen sometimes excluded) black, club feebly or not at all infuscated. Clothed with stramineous and brown scales, becoming white on under parts.

Rostrum scarcely as long as prothorax, on basal third with fine lines and rows of punctures partially concealed by scales, elsewhere with fine naked punctures. Prothorax slightly transverse, sides strongly rounded; punctures normally concealed. Elytra distinctly wider than prothorax, parallel-sided to beyond the middle; with rows of large punctures, really wider than interstices, but appearing somewhat narrower through clothing. Under surface with crowded, normally concealed punctures; two basal segments of abdomen large, feebly convex in middle, the second decidedly longer than fifth. Length, 2·5-3 mm.

♀. Differs in having the rostrum slightly longer, thinner, and clothed only at extreme base, and the two basal segments of abdomen larger and more convex.

Hab.—South Australia: Lucindale (B. A. Feuerheerdt).

The elytra have numerous broken lines of pale scales, the interruptions due to brown ones, which so closely resemble the derm that this appears to be irregularly abraded; on the pronotum the brown scales form a vitta (dilated to the base) on each side of a pale median line.

ENCOSMIA RUFICORNIS, n. sp.

♂. Castaneous. Rather densely clothed with scales, variegated on the upper surface, white on the under parts.

Rostrum the length of prothorax, with a median carina to apical third, and less distinct ones between it and the sides, alternated with rows of punctures partially concealed by scales, apical third with sharply defined, naked punctures. Prothorax about as long as the median width; with dense punctures, mostly partly concealed. Elytra distinctly wider than prothorax, parallel-sided to beyond middle; with rows of large punctures, wider than the interstices, but in most places (owing to the scales) appearing decidedly narrower. Under surface with dense punctures, each containing a scale; two basal segments of abdomen feebly depressed in middle, the second no longer than fifth. Length, 3·25-3·75 mm.

♀. Differs in having the rostrum slightly longer and thinner, the median carina feeble and without others, the abdomen evenly convex, and the second segment slightly longer than fifth.

Hab.—Western Australia: Mount Barker and Swan River (A. M. Lea).

In general appearance like some specimens of *E. fasciata*, but distinguished by the entirely pale antennae. The scales on the upper surface are mostly stramineous and pale brown, but form several dark brown (on one specimen almost black) spots; of these there are two or four on the prothorax, and from four to eight on the elytra; on one specimen the dark prothoracic spots are conjoined to form an irregular vitta on each side of a pale median line, and on each of its elytra there is a distinct dark spot just before, and one just below the summit of the apical slope; the lower one appears much as the similarly placed one on *fasciata*, but on the other specimens it is less defined.

ENCOSMIA ALBIFASCIA, n. sp.

♂. Castaneous. Moderately clothed with white scales, the upper surface, in addition, with inconspicuous brown ones.

Rostrum about as long as prothorax, with fine carinae and rows of punctures on basal third, partly concealed by scales, elsewhere with sharply defined, naked punctures. Prothorax about as long as the median width; punctures dense and mostly well defined. Elytra scarcely wider than widest part of prothorax, parallel-sided to near apex; with rows of large punctures, much wider than interstices, but in places (owing to clothing) appearing narrower. Two basal segments of abdomen very feebly convex in middle, the second just perceptibly shorter than fifth. Length, 2-2·25 mm.

♀. Differs in having the rostrum thinner, clothed only at extreme base, without carinae, and with finer punctures; two basal segments of abdomen larger, more convex, and the second conspicuously longer than fifth.

Hab.—Western Australia: Albany (R. Helms), Mount Barker (A. M. Lea).

On the sides of the prothorax the scales are rather dense, but even there the punctures are traceable; on each side of the middle of the base there appears to be a small naked spot, but this is due to the scales there being of almost the exact shade of colour of the derm; the elytra at first glance appear to have naked spaces—these are also due to the scales there being similarly coloured to the derm on which they rest; the white scales (in addition to many elsewhere) form a distinct postmedian fascia, followed by an apparently denuded one, between which and the apex the white scales are fairly dense but irregularly placed; where the white scales are densest each of the seriate punctures contains a white scale. On the under surface the punctures are more clearly defined than is usual in the genus, owing to the small size of their contained scales.

ENCOSMIA CURVIROSTRIS, n. sp.

♂. Castaneous. Upper surface with pale stramineous and inconspicuous brown scales, becoming white on under parts.

Rostrum slightly longer than prothorax, with a fine median carina, sides clothed to middle; elsewhere with dense and fine, naked punctures. Prothorax about as long as the basal width, sides strongly rounded; with crowded more or less concealed punctures. Elytra distinctly wider than prothorax; with rows of large, subquadrate punctures, wider than interstices, but mostly partly concealed. Two basal segments of abdomen feebly depressed in middle, second distinctly longer than fifth. Length, 2-2·25 mm.

♀. Differs in having the rostrum thinner and more strongly curved, clothed only at the extreme base, and without a median carina, abdomen strongly convex and second segment longer (fully twice the length of fifth).

Hab.—South Australia: Yorke Peninsula (Capt. S. A. White), Lucindale (B. A. Feuerheerdt); Western Australia (J. Faust from — Dohrn).

The elytral clothing is somewhat suggestive of *E. interrupta*, and *E. albifascia*, but the species differs from the former in its pale under parts, and from the latter by the abdomen; the clothing is also suggestive of *Epamaebus ziczac*, which, however, differs in several generic features. The patches of brownish scales on the upper surface so closely resemble the derm on which they rest that they look like denuded spots; there is a small one on each side of the base of the prothorax, and many angular ones on the elytra, frequently conjoined to form interrupted fasciae or zigzag markings. The pale scales are mostly true rounded ones, not at all setose in appearance. The club is really no darker than the rest of the antennae, but when the pubescence is matted with gum it appears to be somewhat infuscated. The curvature of the female rostrum is unusually strong.

ENCOSMIA BIVITTATA, n. sp.

♂. Dark castaneous, head, rostrum and funicle darker; club, scutellum, metasternum and part of abdomen black. Moderately clothed with scales, variegated and often setae-like on upper surface; white on under parts.

Rostrum the length of prothorax, with three well-defined costae from base to apical third (where the antennae are inserted), alternating with rows of partially concealed punctures, apical third with sharply defined, naked punctures. Prothorax slightly longer than the median width; with crowded punctures, concealed beneath vittae only. Elytra distinctly wider than prothorax; with rows of large punctures, in places partly concealed by scales. Two basal segments of abdomen faintly depressed along middle, the second just perceptibly shorter than fifth. Length, 2·75-3 mm.

♀. Differs in having the rostrum somewhat longer, with only a median carina, and that more obtuse and clothed for a shorter distance; the two basal segments of abdomen evenly convex, and the second larger.

Hab.—Tasmania: Strahan, in April (Aug. Simson).

In general appearance like an *Eniopea*, but with the generic characters of *Encosmia*. Of the pair taken by Mr. Simson, only the extreme base of the abdomen of the male is black, but on the female the four basal segments are black. On the prothorax there is a thin vitta of whitish scales on each side, the vittae continued on the elytra till they curve round and meet on the suture about half-way down the apical slope; about the middle of the elytra there is a feeble pale fascia, then

a rather wide dark one, a thin pale one (almost absent from the male) and then another dark one; elsewhere the scales are mostly stramineous or brownish.

ENCOSMIA BASALIS, n. sp.

Castaneous; club, scutellum and metasternum more or less deeply infuscated. Rather densely clothed with scales, variegated on the upper surface, pale on the under parts.

Rostrum the length of prothorax, with three well-defined carinae on basal two-thirds, alternated with rows of punctures, partly concealed by scales; apical third with sharply defined, naked punctures. Prothorax as long as the median width; punctures dense, concealed on sides, but fairly distinct elsewhere. Elytra conspicuously wider than prothorax; with rows of large punctures, wider than interstices, but appearing much smaller through clothing. Two basal segments of abdomen gently convex in middle, the second in middle the exact length of fifth. Length, 2·5 mm.

Hab.—Western Australia: Swan River (A. M. Lea), unique.

The scales are less dense than on *E. adelaidae* and do not form a pale cross on the elytra, the club is darker, and the elytra are slightly wider in proportion. On the pronotum the sides are fairly evenly clothed with pale scales, and there is a thin pale median line, elsewhere the scales are brown, but not individually distinct; on the elytra there is a large, pale, roughly semicircular basal patch, followed on each side by a large irregular triangle of dark scales, the triangles meeting at the suture, and very wide on the sides; on the middle of the apical slope there is a large asymmetrical patch of whitish and yellowish scales. The scales on the under surface have a greenish or bluish gloss, becoming golden on the sides. The two basal segments of abdomen are evenly, although not strongly, convex in the middle, but as there is a shallow depression on the apical segment, and the rostrum is acutely tricarinate the type is presumably a female.

ENCOSMIA VARIEGATA, n. sp.

♀. Black, sides of elytra and tip of prothorax castaneous, legs (except coxae) and antennae (except club) castaneous. Densely clothed with variegated scales on upper surface, becoming white on under parts.

Rostrum rather thin, scarcely the length of prothorax; with dense and sharply defined punctures on basal half becoming sparser and smaller in front. Prothorax slightly transverse, punctures normally concealed. Elytra not much wider than widest part of prothorax; with rows of large punctures, appearing small through clothing, and in parts almost concealed. Two basal segments of abdomen large and convex, the second distinctly longer than fifth. Length, 2·25 mm.

Hab.—Western Australia: Swan River (A. M. Lea), unique.

The prothorax is densely plated with pale scales, having a greenish gloss, changing to golden or stramineous; there is a narrow stramineous median line, on each side of which the scales are less dense than elsewhere, and a small dark spot on each side of the base; on the basal two-thirds of elytra the scales are mostly chocolate-brown varied with pale spots, and short interrupted bands, on the apical third the clothing is as dense as on the prothorax, and similarly coloured, but there is a small dark spot on each side of the suture (much as on many specimens of *E. fasciata* and *E. ruficornis*). The club is darker than the rest of the antennae, but is decidedly paler than the rostrum. In some lights a distinct shining median line may be seen from the base to near the apex of the rostrum, but it cannot be regarded as a true carina.

ENCOSMIA PULICOSA, n. sp.

♀. Dark castaneous, head, rostrum and most of under surface blackish, antennae pale castaneous, club and part of funicle infuscated. Densely clothed with dingy whitish-grey scales, on the upper surface varied with dark brown.

Rostrum the length of prothorax, rather feebly curved; with dense and small punctures, becoming smaller and sparser in front. Prothorax about as long as the median width; with crowded, concealed punctures. Elytra distinctly wider than prothorax; with rows of large, quadrate punctures, wider than interstices but appearing much smaller through clothing, and frequently concealed. Under surface with crowded, concealed punctures; two basal segments of abdomen large and convex, the second almost twice the length of fifth. Length, 3·5 mm.

Hab.—Victoria: Sea Lake (J. C. Goudie's No. 622).

The scales are so dense that the body parts are completely plated; they are of a rather muddy whitish-grey, without gloss on the under surface and legs, but mixed with chocolate-brown on the upper surface; on the head there are two small irregular dark spots; on the pronotum there is a vitta on each side of a pale median line, each vitta narrow in front and dilated to base, with a few brown scales scattered singly; on the elytra the pale and brown scales are in about equal proportions, and very irregularly intermingled.

ENCOSMIA SUTURALIS, n. sp.

♂. Castaneous; head (but not rostrum), club, scutellum, suture and under surface black or blackish. Rather sparsely clothed with thin, depressed scales or setae, stramineous on the upper surface, white on the under parts.

Rostrum rather feebly curved, scarcely the length of prothorax; with fine carinae, alternated with rows of partly concealed punctures on basal half, elsewhere with small naked punctures. Prothorax slightly transverse, with dense and well defined punctures becoming partly concealed on sides. Elytra thin and parallel-sided to near apex, very little wider than widest part of prothorax; with rows of large punctures, usually wider than the interstices. Two basal segments of abdomen slightly depressed in middle, the second, in middle, just perceptibly shorter than fifth. Length, 2·5-3 mm.

♀. Differs in having the rostrum thinner, more curved, without carinae, seriate punctures or clothing, two basal segments of abdomen convex, and the second distinctly longer than fifth.

Hab.—Tasmania: Mount Wellington (A. M. Lea).

A narrow species distinct by its dark suture. On some specimens part of the scape is deeply infuscated, and on one of these (a male), the femora are infuscated in the middle.

ENCOSMIA MEDIOGLABRA, n. sp.

Castaneous; club, scutellum and metasternum black or infuscated. With white scales, dense and uniform on the under surface and legs, dense on sides only of pronotum, clothing the suture (except at summit of apical slope) and forming spots on shoulders, in the middle near suture, and on the apical slope.

Rostrum thin, moderately curved, and the length of prothorax; with fine carinae, alternated with rows of partially concealed punctures on basal third, naked punctures elsewhere. Prothorax feebly transverse; with crowded punctures, partly concealed on sides. Elytra distinctly wider than widest part of prothorax;

with rows of large punctures in deep striae. Two basal segments of abdomen large and rather strongly convex, the second decidedly longer than fifth. Length, 2·5 mm.

Hab.—New South Wales: Sydney (Dr. E. W. Ferguson), unique.

The white clothing of the elytra, if at all constant, should render this species a very distinct one. The postmedian spots appear like an abbreviated fascia. There are some dark scales on the elytra, but they so closely resemble the derm on which they rest that they are not individually traceable. The type is probably a female, as the two basal segments of its abdomen are evenly convex; and the females of several species have the rostrum finely carinated towards the base.

Encosmia apicalis, n. sp.

♂. Black, prothorax and elytra dark brown, antennae reddish, the club blackish. Densely clothed with scales, whitish and chocolate-brown on upper surface, white on under parts.

Rostrum wider than usual, the length of prothorax; basal three-fifths with a distinct median carina, and some finer ones alternated with rows of partially concealed punctures, apical part with the median carina continued as a shining line, and with rather dense naked punctures. Prothorax moderately transverse; punctures concealed. Elytra rather wide; with rows of large punctures, wider than interstices, but mostly obscured by clothing. Two basal segments of abdomen large, rather feebly convex in middle, the second almost twice the length of fifth. Length, 2·75-3 mm.

♀. Differs in having the rostrum thinner and more curved, without carinae or seriate punctures, and clothed only about extreme base, and abdomen more convex.

Hab.—New South Wales: Blue Mountains (Dr. E. W. Ferguson).

A rather robust species, with a wide rostrum and distinctive clothing. On the pronotum the dark scales form an irregular vitta on each side of a narrow pale median line and a few are scattered on the sides; on the elytra they clothe the surface, except for a line of whitish scales on the apical third of the suture, and an inconspicuous basal edging.

Encosmia montana, n. sp.

♂. Castaneous, club and metasternum black or blackish. Moderately clothed with thin, depressed scales or setae, stramineous on the upper surface, white on the under parts.

Rostrum the length of prothorax, basal two-thirds with fine carinae, alternated with rows of partially concealed punctures, apical third with naked punctures. Prothorax moderately transverse, densely granulate-punctate, sculpture slightly obscured on sides. Elytra rather narrow but distinctly wider than prothorax; with rows of large, quadrate punctures. Abdomen with two basal segments depressed along middle, the second slightly shorter than fifth. Length, 3-3·5 mm.

♀. Differs in having the rostrum thinner and slightly longer, median carina shorter and less conspicuous, seriate rows of punctures ill-defined, and clothed only at extreme base; two basal segments of abdomen larger, evenly convex, and the second decidedly longer than fifth.

Hab.—New South Wales: Mount Kosciusko (5,000 feet, in March, R. Helms, and W. E. Raymond); Victoria: Alps (H. W. Davey).

Allied to *E. blackburni*, but clothing sparser, and club and metasternum dark; *E. melanostetha* is a smaller species with pale club. On some of the specimens

taken by Mr. Raymond the metasternum is scarcely darker than the elytra; on four taken by Mr. Helms it is deep black, and the black extends to the prosternum, and to two or three segments of the abdomen; the only specimen received from Mr. Davey has the tip of the prothorax infuscated. On the prothorax the scales are more numerous on the sides than middle, although there is a feeble median line; on the elytra they are compacted to form feeble spots.

ENCOSMIA NIGRICLAVA, n. sp.

♂. Pale castaneous, club black. Sparsely clothed with thin scales or setae, stramineous on upper surface, white on under parts.

Rostrum rather thin and slightly curved, with fine carinae, alternated with rows of partly concealed punctures on basal three-fourths. Prothorax moderately transverse, with crowded, distinct punctures. Elytra rather thin; with rows of large, subquadrate punctures wider than striae. Two basal segments of abdomen slightly depressed in middle, the second slightly shorter than fifth. Length, 2 mm.

Hab.—Western Australia: Mount Barker (A. M. Lea), unique.

A small species, allied to the preceding, but considerably smaller, and entirely pale, except for the clubs and eyes. The type is probably somewhat abraded, as the clothing is unusually sparse, on the elytra it appears to be compacted into feeble spots. The antennae are inserted less than one-third from apex of rostrum.

ENCOSMIA MINOR, n. sp.

♂. Dark castaneous-brown, rostrum and legs paler, head and club deeply infuscated. Rather densely clothed, with scales, somewhat variegated on upper surface, white on under parts.

Rostrum rather thin, basal two-thirds with fine carinae, alternated with rows of partially concealed punctures. Prothorax slightly transverse; with dense, partially concealed punctures. Elytra distinctly wider than widest part of prothorax, very feebly dilated to beyond the middle, with rows of large, partially concealed punctures. Two basal segments of abdomen depressed in middle, the second in middle the length of fifth. Length, 1·75-2 mm.

Hab.—Western Australia: Mount Barker (R. Helms).

A small, obscure species. The scales on the upper surface are mostly whitish or stramineous, inconspicuously variegated with small ill-defined brown spots.

DICROCIS, n. g.

Head small. Eyes lateral, briefly ovate, finely faceted. Rostrum longer than prothorax, thin and distinctly curved. Antennae moderately long, scape slightly shorter than funicle, inserted slightly nearer apex than base of rostrum, resting in a scrobe that touches the front of the eye, two basal joints of funicle rather long. Prothorax about as long as the median width, sides feebly dilated from base to middle, and then strongly narrowed to apex; ocular lobes and median incurvature of under surface very feeble. Scutellum small. Elytra cordate, much wider than prothorax. Two basal segments of abdomen large, the first longer than second, fifth slightly shorter than second. Femora stout, edentate; front tibiae falcate; tarsi with third joint rather widely bilobed, claw joint thin, moderately exserted, and with small divergent claws.

In Blackburn's table of the Erirhinides (*Trans. Roy. Soc. S. Aust.*, 1894, 148) this genus could be associated with *Oenochroma* and *Olbiodorus*; from the former it is distinguished by the tips of the tibiae, and by the short basal joint of the

hind tarsi (it is conspicuously shorter than the basal joint of the front tarsi). From the latter genus it is also distinct by the tips of the tibiae, by the much smaller claw joint, and by the longer rostrum. The falcation of the tibiae is less pronounced than on *Oenochroma* but more than on *Olbiodorus*. The species also are decidedly shorter and broader than those of the genera named. At first glance they resemble species of *Dicomada* or large ones of *Cydmaea*. On *D. leucomelas* each front tibia is terminated by a stout spine that arches round the apex, close to it the inner apical process is clothed with a pointed fascicle, causing the apex to appear bispinose, or finely cleft; the middle tibiae are similar at the apex, but are less strongly falcate; on *D. albus* the apical processes of the front and middle tibiae are longer, so that the tips appear more conspicuously cleft or bispinose; on *D. banksiae* they are intermediate between those of the other species. On the female of *banksiae* the antennae are inserted slightly nearer the base than the apex of the rostrum; on that species also the ocular lobes are supplied with a feeble fringe, but on the others no fringe is visible, and the lobes might fairly be regarded as absent. They are all densely squamose.

Type of genus, *D. leucomelas*.

Dicrocis leucomelas, n. sp.

Black. Densely clothed with black scales, interspersed with snowy-white ones.

Head with crowded, concealed punctures. Rostrum slightly longer than prothorax, parallel-sided and with closely placed rows of punctures to insertion of antennae, thence somewhat thinner, and with smaller punctures that are not crowded. Second joint of funicle thinner and slightly longer than first. Prothorax evenly convex; with fairly dense and small, normally concealed punctures. Elytra about one-third longer than wide, and about one-third wider than prothorax; striate-punctate, punctures of moderate size (about one-third the width of interstices) but normally almost or quite concealed, the interstices themselves with dense, minute punctures. Length, 3·5-4 mm.

Hab.—Western Australia: Albany (Pascoe's collection in British Museum), Karridale (A. M. Lea).

An intensely black species, even to the claws. The white scales are sparsely scattered and usually in singles, but they are fairly dense on the tibiae, and the under surface of the femora, they are not more numerous on the abdomen than on the elytra. The two specimens examined appear to be males.

Dicrocis albus, n. sp.

Black. Densely clothed with white scales, feebly variegated on the upper surface.

Head with crowded, concealed punctures. Rostrum slightly longer than prothorax, basal two-fifths with closely placed rows of fairly large punctures, suddenly becoming much smaller and sparser. Second joint of funicle distinctly thinner and longer than first. Length, 3·5-4·25 mm.

Hab.—Western Australia: Perth (Blackburn's collection), Pinjarrah (A. M. Lea).

The outlines of the prothorax and elytra are as in the preceding species, but I have not removed any of the scales to be sure of the finer sculpture. In certain lights, especially on the under surface, the scales have a slight rosy or opalescent gloss; on the upper surface they are feebly mottled with pale yellowish-brown. The specimen from Perth is rather dirty and its scales are ashen-grey, parts of its antennae are obscurely reddish. The two specimens examined appear to be males.

DICROCIS BANKSIAE, n. sp.

♂. Dark reddish-brown, some parts almost black, antennae and tarsi paler. Densely clothed with stramineous or pale fawn-coloured scales on upper surface, white on under surface and legs.

Head with crowded, concealed punctures. Rostrum slightly longer than prothorax, between antennae and base with five narrow costae, alternated with rows of partially concealed punctures; apical two-fifths somewhat narrower, and with smaller but sharply defined punctures. First joint of funicle stouter and slightly longer than second. Prothorax with crowded, concealed punctures. Elytra about one-third wider than prothorax; striate-punctate, punctures fairly large but partly concealed, each with a stout scale, interstices much wider than striae, and with crowded, concealed punctures. Length, 4·5-5·5 mm.

♀. Differs in having the rostrum considerably longer, antennae inserted slightly nearer base than apex of rostrum, and abdomen larger and more convex.

Hab.—South Australia: Lucindale (A. M. Lea).

The white scales are almost invisible from above, but they clothe the lateral interstice of each elytron; they have a silvery look, and in certain lights are faintly opalescent. Each interstice has an irregular, in places semidouble, row of inconspicuous, stouter scales or setae, but they are almost as depressed as the others, and but little larger. On the female the rostrum, if drawn backwards, would almost extend to the abdomen; its costae are quite as distinct as on the male, but they terminate before the middle; beyond them the punctures are decidedly smaller and sparser than on the male. A pair taken, *in cop.* on a species of *Banksia*.

OLIGOCARICIS, n. g.

Head small. Eyes small, lateral, with coarse facets. Rostrum long, thin, parallel-sided, moderately curved. Antennae inserted about one-third from apex of rostrum; scape slightly shorter than funicle, the latter seven-jointed, closely applied to club; club indistinctly jointed. Prothorax small. Elytra rather long, shoulders slightly rounded, parallel-sided to beyond the middle. Prosternum moderately notched in front. Two basal segments of abdomen large, third and fourth drawn backwards at sides, and conjointly slightly longer than fifth. Femora rather finely dentate; third tarsal joint moderately bilobed, claw joint thin, moderately exserted, claws soldered together except at tips.

In Blackburn's table of the Erirhinides (*Trans. Roy. Soc. S. Aust.*, 1894, 148) this genus could be associated with *Agestra*, which has normal claws and larger eyes. The tarsi under a hand power lens appear to be terminated by a single claw, but under a compound power, two claws, separated only close to the tip, become visible. No previously named genus in Australia has similar claws.

OLIGOCARICIS LONGIROSTRIS, n. sp.

Blackish, parts of antennae and of legs obscurely reddish. Clothed with soft scales varying from white to black, but mostly white on under surface and legs.

Head with small punctures, and a partly obscured interocular impression. Rostrum distinctly longer than prothorax; with dense punctures, concealed except in front. Prothorax slightly longer than the median width, base slightly wider than apex, sides rather strongly rounded; with numerous punctures, mostly concealed, but in places sharply defined. Elytra with narrow striae in places containing more or less oblong punctures. Under surface with fairly dense, normally concealed punctures. Length, 3 mm.

Hab.—North-western Australia: Behn River (R. Helms); Northern Territory: Adelaide River (British Museum).

The head is almost bald; on the prothorax the white scales form an irregular median line, and still more irregular lateral ones, on the elytra they are dense about the base, and about the summit of the apical slope, where many of the adjacent scales are fawn-coloured. The rostrum has numerous scales, more or less seriate in arrangement, and masking punctures, which are probably in five rows; the scales terminate suddenly at the base, and less suddenly in front of the insertion of antennae. The first joint of the funicle is as long as the second and third combined, the third and fourth slightly decrease in length and width, the fifth to seventh are each about as long as the fourth, but increase in width, the seventh is closely applied to the club, and a compound power is needed to see it clearly. The elytral striae, where not concealed by scales, are seen to be much narrower than the interstices, near the suture they are almost impunctate, but elsewhere they contain more or less oblong punctures; on each side near the base there are two short ones enclosing a narrow ellipse of white scales. The scutellum appears to be absent. The two specimens examined appear to be males.

Apionides.

APION.

Prior to publishing new names in this immense genus I checked them with the catalogue by Gemminger and Harold, and with the Zoological Records as far as available, but unfortunately did not check them with some other generic names, that in the recent catalogue of the subfamily (Wagner, Junk, Col. Cat. Curc., Apioninae, Berlin, 1910) are now placed as subgenera of *Apion*; so that now some fresh names are required.

APION MERIDIONALE, new name.

A. cylindrirostre Lea, 1910.

Piezotrachelus cylindrirostris was used by Wagner in 1908, and the generic name now being regarded as of subgeneric rank only, the Australian species is renamed as above.

APION ILLAWARRENSE, new name.

A. longicolle Lea, 1910.

Piezotrachelus longicollis was used by Gerstaeker in 1854; in Gemminger and Harold it is noted as a synonym of *P. asphaltinus*, but in the recent catalogue it is given as a valid species. Sharp, however, used the name for an American species of *Apion* in 1889, his name now being recorded as a synonym of *A. macrothorax*.

APION MACLEAYENSE, new name.

A. inornatum Lea, 1910.

A. inornatum having been used for an African species of the subgenus *Aspidapion* in 1904, the Australian species is renamed as above.

APION TERRAE-REGINAE Blackb.

This species occurs in the Northern Territory and North-western Australia as well as Queensland. The female differs from the male in having the rostrum slightly longer, thinner, shining, and with smaller punctures although sharply defined and rather dense.

APION ARGUTULUM Pasc.

This species occurs in New South Wales, Queensland, Northern Territory and North-western Australia. The pubescence on its upper surface is extremely fine, and is obscured on specimens at all greasy. Many specimens have a faint metallic gloss; the legs are usually black, but occasionally are dark reddish-brown.

APION CONVEXIPENNE Lea.

Named originally from Townsville in Queensland, but occurs also on Moa, Cornwallis, Mabuiag and Thursday Islands in Torres Straits, and in Northern Territory and North-western Australia.

APION INORNATUM Lea.

Three specimens from Bowen, two from Bundaberg, one from Townsville, and another from Mabuiag Island appear to belong to this species (hitherto known only by the type from New South Wales). The species is allied to *A. argutulum*, but the prothorax has a single strong constriction near the apex, and the base decidedly wider than on that species. The size ranges 2-2·5 mm. The rostrum of the female is about one-fourth longer than that of the male, and is slightly more curved.

APION AGONIS Lea.

A female, from Mabuiag Island, that appears to belong to this species, differs from the type female in having the apical half of the rostrum slightly thinner, more shining, and with less distinct punctures.

APION CONGESTUM Lea.

A specimen from Cairns may represent a variety of this species; its derm, instead of being of a dark brown, is quite black, and the elytral clothing is white, except for a short and feeble transverse median fascia.

APION PILISTRIATUM Lea.

A specimen from Magnetic Island may represent a variety of this species. It differs from the type female in having the rostrum slightly longer, stouter, and less shining, the tarsi entirely black, and the apical joints of the funicle and the club blackish.

APION NIGROSUTURALE Lea.

Some specimens from the Northern Territory (Darwin and the Mary River) belong to this species, but differ from the types in having the elytral clothing practically uniform throughout, except that on some of them the pubescence is sparser about the middle of the elytra than elsewhere.

APION IMMUNDUM Lea.

Eight specimens from Port Lincoln probably belong to a variety of this species; the female has the very long rostrum typical of the species, but it is slightly stouter and straighter, and has larger punctures on its sides and upper surface than on the types; the males are indistinguishable from normal males.

APION HOBLERAE Lea.

Numerous specimens from Parachilna (South Australia) agree well with the types of this species, but some of them have the elytral clothing less variegated;

a male from Gayndah (Queensland) probably also belongs to the species but its clothing is entirely white, its rostrum is paler, and only slightly infuscated about the base.

APION ASTRI, n. sp.

♂. Black, subopaque. Moderately clothed with white pubescence.

Rostrum slightly longer than prothorax, moderately curved, moderately wide, and with fairly strong punctures behind antennae; thinner, shining, and with small punctures in front of them. Prothorax feebly constricted near apex, which is about half the width of base; with numerous partly concealed punctures. Elytra moderately wide; strongly striate-punctate, interstices with small, dense punctures. Length (excluding rostrum), 2-2·25 mm.

♀. Differs in being slightly more robust, rostrum slightly longer and thinner, and abdomen more convex.

Hab.—South Australia: Callington in January, on *Aster* sp. (J. G. O. Tepper), Murray River (A. H. Elston), Murray Bridge (A. M. Lea).

A moderately pilose, strongly striated species, allied to *A. subopacum*, from which it differs in having the pubescence longer, not condensed to form a distinct spot on each side of the scutellum, and sparser in the middle of elytra, so that there appears to be a fairly large, dark, inconspicuous spot there, it is somewhat denser on the sides of the sterna than elsewhere, but does not form a conspicuous stripe on each side. On sixteen specimens not one has the rostrum at all reddish, and that of the female is shorter than on that species. On two specimens the legs are obscurely reddish, but on all the others they are deep black. On some specimens there appears to be a faint medio-basal impression on the pronotum, but on most of them it is not traceable.

APION TRILOBICOLLE, n. sp.

♂. Black, polished and glabrous.

Head with a shallow interocular impression, some sharply defined punctures near eyes. Rostrum rather short (scarcely the length of prothorax), straight, comparatively wide, parallel-sided and subopaque. Antennae somewhat shorter and stouter than usual. Prothorax rather thin, slightly constricted near apex, and again near base, which is not wider than apex; with a few punctures in the sub-basal constriction, but elsewhere impunctate. Elytra strongly convex, almost twice the width of prothorax at base, and more than twice about the middle; with narrow striae, impunctate about suture and base, but with rather large punctures elsewhere; interstices impunctate. Length, 2·25-2·75 mm.

♀. Differs in having the rostrum slightly longer (as long as the prothorax), thinner, and shining.

Hab.—Queensland: Cairns district (A. M. Lea), Malanda, Cedar Creek (Dr. E. Mjöberg).

Of the black species with the rostrum straight or almost so, this one may be distinguished from *A. australasiae*, *A. niveodispersum* and *A. bimaculialbum* by its glabrous upper surface. It is close to *A. tenuistriatum*, and has somewhat similar striae, some of which contain large punctures, but the rostrum is shorter, and the interocular depression is larger (not punctiform as on that species). The narrow prothorax is widest in the middle, and its sides are distinctly trilobed.

APION VARIROSTRE, n. sp.

♂. Black, shining and glabrous.

Head with a shallow interocular impression, and some distinct punctures near eyes. Rostrum rather short (distinctly shorter than prothorax), straight; with sparse but fairly distinct punctures, disappearing in front. Prothorax thin, base and apex equal, sides constricted near both apex and base; with minute scattered punctures, and a few larger ones on sides near base. Elytra much wider than prothorax at base, and more than twice as wide about middle; with narrow striae, containing distinct punctures except towards base and suture. Length, 2-2·5 mm.

♀. Differs in having the rostrum much thinner, slightly longer and the antennae thinner, with the scape obscurely reddish.

Hab.—Queensland: Mount Tambourine (A. M. Lea).

Allied to *A. tenuistriatum*, and the preceding species, and with similarly trilobed sides of prothorax, elytral striae and punctures, but the latter smaller. The male is decidedly close to the male of the preceding species, but the female is at once distinct by its much thinner rostrum; in both sexes it is shorter than the prothorax. Three females are slightly shorter than three males, and have the scape reddish, in the males the antennae are entirely black.

APION STRIATIPENNE, n. sp.

Black, shining and glabrous.

Head with a shallow interocular depression, and a few punctures near eyes. Rostrum shorter than prothorax, straight, rather thin, and almost impunctate. Prothorax thin, distinctly constricted near apex and base, almost impunctate. Elytra comparatively narrow, much wider than prothorax at base, and more than twice its width about middle; with narrow striae, a few of which contain small punctures. Length, 2 mm.

Hab.—New South Wales: Illawarra (H. W. Cox), Stanwell Park (A. M. Lea).

In general appearance close to the preceding species, and with sides of prothorax trilobed, but the elytral striae more regular, and the punctures scarcely indicated, although close to the sides and from certain directions some of them are moderately distinct. The two specimens taken are probably females.

APION MEDNONSTRIATUM, n. sp.

♂. Black, shining and glabrous.

Head with a very feeble depression between the eyes, and with a few minute punctures. Rostrum about the length of prothorax, not very wide, almost straight; with a row of punctures on each side from base to near apex, and fairly numerous ones on the margins behind the antennae. Prothorax narrow, sides feebly trilobed, base no wider than apex, but with some distinct punctures. Elytra narrow, strongly convex, greatest width about twice that of prothorax; with a narrow impunctate stria on each side of suture, and two near each side, the latter with distinct punctures in their middle, elsewhere without punctures or striae. Length, 2·25 mm.

Hab.—Queensland: Cairns district (A. M. Lea), unique.

A narrow, highly convex species, with an almost straight rostrum and distinctive elytra. The type is a male, as the tip of its aedeagus is protruding.

APION BASIINFLATUM, n. sp.

Black, shining. Legs feebly pubescent.

Head opaque, and with numerous punctures. Rostrum with basal fourth rather wide and opaque, then suddenly narrowed, curved, shining and cylindrical. Prothorax rather short, base slightly wider than median length, and much wider

than apex, sides feebly constricted near apex; with small, scattered punctures. Elytra robust, base not much wider than prothorax; strongly punctate-striate, interstices almost impunctate. Length, 2 mm.

Hab.—Northern Queensland (Blackburn's collection).

A strongly striated species allied to *A. argutulum*, *niveodispersum*, *agonis* and *macleayense*, from all of which it is distinguished by the rostrum; in addition *argutulum* has a narrower and trilobed prothorax, *niveodispersum* has conspicuous white clothing in parts, *macleayense* has prothorax strongly constricted near apex, and longer and thinner legs, and *agonis* is larger, with less distinct punctures in the striae. The rostrum probably varies sexually, but in the type, which is probably a female, it is fairly wide at the base and gradually dilates to the basal fourth, when it is suddenly and strongly narrowed to a thin cylinder, which is evenly curved; the thin part is as long as the prothorax. Two specimens from Cairns (Dr. E. W. Ferguson) are probably males; they differ in being smaller, shorter, the rostrum less suddenly, but still strongly narrowed at the basal third, slightly stouter, and less cylindrical and subopaque. All three specimens have a very faint metallic-green gloss.

Apion torresianum, n. sp.

♂. Black, shining. Under surface and legs with sparse, white pubescence, but conspicuous on sides of mesosternum and metasternum, and on front coxae.

Head opaque and with numerous punctures. Rostrum slightly longer than prothorax, moderately curved, fairly wide on basal fourth, then narrowed and becoming cylindrical and shining towards apex. Prothorax about as long as the basal width, slightly constricted near apex, which is much narrower than base; with numerous rather small but sharply defined punctures. Elytra robust, widest just before the middle; with deep set punctures in rather narrow striae. Length, 2·25 mm.

Hab.—Torres Strait: Moa Island (C. T. McNamara).

Allied to *A. niveodispersum*, but slightly larger, with rostrum slightly longer and without white pubescence about scutellum, or in front of eyes, and sparser on under surface and sides of prothorax. A specimen from Mabuiag Island is probably a female of the species; it differs from the type in being somewhat narrower, with the rostrum longer and thinner, the punctures on the prothorax less distinct, and the elytral striae narrower, with less distinct punctures.

Apion clavicorne, n. sp.

♂. Black, shining and glabrous.

Head with a feeble interocular impression, and with a few punctures near eyes. Rostrum slightly longer than prothorax, moderately curved; with an irregular row of punctures on each side of upper surface, from base to near apex, and with fairly dense ones on the sides. Antennae with club longer than usual, and with fairly long setae. Prothorax narrow, sides trilobed, base no wider than apex; with a few distinct punctures on and about subbasal constriction. Elytra strongly convex, much wider than prothorax at base, and more than twice its width across middle; with a narrow stria on each side of suture, and two on each side, the latter with a few distinct punctures. Length, 2·25-3 mm.

♀. Differs in having the rostrum longer, thinner, and more curved, and the club more compact.

Hab.—Queensland: Cairns district (A. M. Lea), Cedar Creek, Malanda (Dr. E. Mjöberg).

The combination of curved rostrum, glabrous surface, trilobed sides of prothorax, and peculiar striae, distinguish this species from all others with black body and legs. The middle of each elytron is without striae as on *A. mednonstriatum*, but there are two short rows of punctures there, one row sometimes consisting of two punctures only. In general appearance the species strongly resembles *Myrmacicelus formicarius* on a small scale, but the antennae, tarsi, etc., are different. A few specimens have the scape obscurely reddish.

APION MEDIOPUNCTUM, n. sp.

Black, shining and glabrous.

Head with a shallow interocular impression, and a few punctures near eyes. Rostrum the length of prothorax, gently curved, rather thin and parallel-sided to middle, sides gently incurved between there and apex; a narrow impunctate line along middle, with fairly dense punctures elsewhere. Prothorax narrow, sides trilobed; with a few punctures in the subbasal impression. Elytra strongly convex, much wider than prothorax at base, and more than twice its width about middle; with narrow striae, the first four on each side of suture impunctate, the others with distinct punctures. Length, 2-2·5 mm.

Hab.—Queensland: Cairns district (A. M. Lea).

With the sides of prothorax trilobed as in the preceding species, but all striae of elytra distinct, except that some of them vanish before the shoulders, and containing distinct punctures towards the sides. The first four striae on each elytron are impunctate, the fifth from some directions appears to be without punctures, but from other directions they are sharply defined. Four specimens taken by myself appear to be all males (one of them has the scape obscurely reddish). Two from Northern Queensland (Blackburn's collection) and two from Malanda (Dr. E. Mjöberg) appear to be females; they have the rostrum slightly longer, thinner and more curved and its sides less incurved near the apex.

APION INFLATICOLLE, n. sp.

Black, shining and glabrous.

Head with a shallow interocular impression, and with some coarse punctures near eyes. Rostrum rather thin, moderately curved, slightly longer than prothorax; subopaque and with fairly distinct punctures on basal third, shining and with smaller punctures elsewhere. Prothorax rather narrow in front, sides rather strongly dilated to near base and then suddenly narrowed to base itself; with numerous small punctures, larger on sides of base than elsewhere. Elytra much wider at base than prothorax, and more than twice its width about middle; with narrow striae throughout, not containing punctures, but a few indicated near sides; sutural interstice rugose posteriorly. Length, 2·5-3 mm.

Hab.—Queensland: Mount Tambourine (Drs. R. H. Pulleine and E. Mjöberg).

The combination of prothorax strongly dilated to near base, rostrum moderately curved, regular elytral striae almost without punctures, and glabrous surface will readily distinguish from all other black species of the genus described from Australia. Two of the specimens have slightly longer and thinner rostrum and slightly narrower prothorax than two others and are probably females, the others probably being males.

APION INTEROCULARE, n. sp.

Black, shining and glabrous.

Head with a shallow interocular depression, and with coarse punctures between and close behind eyes. Rostrum slightly longer than prothorax, moderately curved, thin, cylindrical, shining, and with minute punctures, except that the basal third is wider, opaque, and with moderately large punctures. Prothorax with sides slightly dilated to beyond the middle, and then narrowed to base, which is slightly wider than apex; with a few distinct punctures on sides of base. Elytra about middle more than twice the width of prothorax; with narrow striae, mostly containing conspicuous punctures. Length, 1·5-2 mm.

Hab.—Queensland: Cairns district, abundant (A. M. Lea), Northern Queensland (Blackburn's collection), Malanda (Dr. E. Mjöberg).

In general appearance strikingly close to *A. stilbum*, but with coarse punctures about the eyes; on that species there is a shallow depression between the eyes and no punctures there. On *A. illawarrense* there are some rather sharply defined punctures between the eyes, but they are distinctly smaller, and there is a shallow groove in front; that species also is considerably larger, with a longer rostrum and prothorax. Two striae on each side of the suture are without punctures, in the next two some punctures are moderately distinct from some directions, and invisible from others; the rest have conspicuous punctures, except that they disappear towards the base and apex. The sutural and marginal interstices are somewhat rugose about the apex. The sexes differ to a slight extent in the rostrum.

Apion varistriatum, n. sp.

Black, shining and glabrous.

Head with a shallow interocular impression, and some sharply defined punctures near eyes. Rostrum moderately curved, longer than prothorax, feebly dilated from base to basal third, then narrow and cylindrical to apex; with a row of small punctures on each side on basal half, the margins near base with fairly dense punctures, elsewhere with sparse and minute ones. Prothorax rather narrow, sides gently rounded in middle and feebly narrowed to base and apex, which are equal; without punctures, except for some sharply defined ones on sides of base. Elytra at middle about twice the width of prothorax; with a narrow sutural stria, at sides with two striae containing distinct punctures and remnants of a third with a few small punctures, elsewhere with very faint striae. Length, 2·25-2·75 mm.

Hab.—Queensland: Mount Tambourine (Dr. E. Mjöberg, H. Hacker and A. M. Lea); New South Wales: Richmond River (Lea).

A highly polished species of which the Richmond River specimen was standing in my collection for years as *A. albertisi*, but evidently in error, as that species was described as being 4 mm. in length, and as having the striae, except the sutural, almost obsolete, whereas on this species there are two distinct striae near each side; the longest specimen is 3·25 mm. with the rostrum, and 2·75 mm. without it. In general appearance it is like *A. stilbum*, but is thinner and the elytral striae are very different. Two of the specimens from Mount Tambourine, in the Queensland Museum, have the elytral punctures more distinct than on the others, but the intermediate striae are even less distinct; but on all of them they vanish near the shoulders. The rostrum of the female is slightly longer and thinner than that of the male, its length being about one-fourth more than that of the prothorax.

Apion atropolitum, n. sp.

Black, shining and glabrous.

Elytra narrow and strongly convex, with a thin impunctate sutural stria, and two on sides with distinct punctures. Length, 2·25-2·75 mm.

Hab.—Queensland: Cairns district (Dr. E. W. Ferguson and A. M. Lea), Cedar Creek (Dr. E. Mjöberg).

The description of the preceding species applies exactly to this one, except that the median striae of the elytra are completely absent; on that species although fine, they are traceable; they are in fact much as on *A. clavicorne*, but the prothorax is not trilobed. It is probably allied to *A. albertisi*, but the presence of punctate striae on the sides should be distinctive. On several specimens the scape is obscurely reddish.

Apion sculpticeps, n. sp.

Black, shining and glabrous.

Head with a faint interocular depression; with some small punctures between and close behind eyes, and dense ones on an opaque surface below them, behind the punctures a few fine striae becoming more distinct on the lower surface. Rostrum about one-fifth longer than prothorax, moderately curved, basal half parallel-sided, between middle and apex gently incurved; with fairly numerous punctures on upper surface, but rather small, becoming sparser and smaller in front, the sides with rather coarse punctures, especially behind antennae. Prothorax narrow, sides gently rounded, base and apex subequal; with scarcely visible punctures except about base, where they are sharply defined on the sides, and fairly distinct in the middle. Elytra slightly beyond middle, more than twice the width of prothorax, striate-punctate. Length, 3 mm.

Hab.—Queensland: Cairns, unique.

With the general appearance of *A. illawarrense*, but rostrum as wide at apex as at base, the rows of punctures on the middle of the elytra are almost as strong, but their striae are different. There are ten striae on each elytron, of which the sutural and marginal ones are impunctate, the others are feeble, but contain distinct punctures, except that they vanish about the shoulders and apex (the tips, however, are slightly rugose), towards the suture both striae and punctures become very feeble, although fairly distinct in certain lights. At first glance the prothorax, except at the extreme base, appears to be impunctate.

Apion melvillense, n. sp.

♂. Black, legs obscurely reddish, parts of the tarsi and the coxae black, antennae flavous, the club and funicle sometimes slightly infuscated. Moderately densely clothed with white pubescence, becoming denser on sides of mesosternum and metasternum, and on under surface of head.

Head with partially concealed punctures. Rostrum scarcely longer than prothorax, gently curved, not very wide at base and decreasing in width to apex; with partially concealed punctures on basal half, shining and with smaller punctures elsewhere. Prothorax almost as long as the basal width, sides evenly and strongly narrowed to apex; punctures fairly dense but partially concealed, and with a faint medio-basal impression. Elytra not twice the width of base of prothorax; striate-punctate, interstices with fairly dense punctures. Length, 1·75-2 mm.

♀. Differs in having the rostrum thinner, slightly longer and clothed only at the extreme base, instead of to about the middle; the elytra also are slightly wider.

Hab.—Northern Territory: Melville Island, abundant (W. D. Dodd).

A small deep black species, of normal shape, with dingy reddish legs, flavous antennae, and white pubescence, which obscures most of the punctures; it is slightly denser about the scutellum, itself glabrous, than on the rest of the upper surface. The clothing is much as on *A. pilistriatum*, but the legs are much darker, and the rostrum is not sexually variable in colour, although on an occasional specimen it is obscurely diluted with red.

Apion pictipes, n. sp.

Black, apical third of rostrum (but not the tip), tibiae, base of femora and antennae (the club infuscated) more or less flavous. Rather sparsely but irregularly pubescent.

Head with coarse, partially concealed punctures, almost vanishing at base. Rostrum slightly longer than prothorax, rather strongly curved, feebly diminishing in width to apex; with rather dense punctures, becoming smaller and sparser in front. Prothorax about as long as the basal width, which is much greater than the apical, sides feebly bisinuate; with dense and fairly distinct punctures, and a small but distinct medio-basal impression. Elytra about the middle almost twice the width of prothorax; strongly striate-punctate, the interstices with minute punctures. Length, 2 mm.

Hab.—Queensland: Cairns district (A. M. Lea), unique.

Allied to *A. condensatum*, *aemulum*, and *hoblerae*, but with much sparser clothing, which is white but inconspicuous, although moderately condensed on sides of prothorax, on the third interstice at base, forms a feeble postmedian fascia to the fourth interstice on each elytron, and is fairly dense on the sides of the metasternum. The curvature of the rostrum is much as on *condensatum*. The prothorax has not the trilobed appearance of several of the entirely black species, although its sides are feebly bisinuate. The type appears to be a male, as its rostrum is thinly clothed almost to the apex.

Apion parvocastaneum, n. sp.

♂. Castaneous-brown, rostrum, suture and parts of tarsi infuscated or blackish. Moderately clothed with whitish pubescence.

Head with partially concealed punctures. Rostrum thin, slightly curved, and slightly longer than prothorax; with minute punctures, concealed about base. Prothorax about as long as the median width, which is slightly more than that of the base, the latter slightly wider than apex; with fairly dense and sharply impressed but partially concealed punctures; medio-basal impression faint. Elytra with outlines subcontinuous with those of prothorax; strongly striate-punctate, interstices with minute punctures. Length, 1·25-1·5 mm.

♀. Differs in having the rostrum slightly longer, thinner and more curved.

Hab.—South Australia: Murray Bridge (A. M. Lea).

A minute species, allied to *A. turbidum*, but even smaller than that species, and much more sparsely clothed, notably on the elytra; also smaller than *A. nigroterminale*, with sparser clothing and much darker legs and rostrum. The elytra are more sparsely clothed about the middle than elsewhere, but there is no distinct seminude space there on any of the six specimens taken. The metasternum is slightly darker than the abdomen.

Apion quadricolor, n. sp.

♂. Reddish-castaneous; interocular space, basal third of rostrum, club, scutellum, suture, shoulders, and margins of elytra, metasternum, coxae, tips of

tibiae and tarsi, black or infuscated; rest of legs flavous. Irregularly clothed with white pubescence, denser about scutellum, before and behind a seminude median space on elytra (extending to the fourth or fifth interstice), and on sides of metasternum than elsewhere; rostrum thinly clothed almost to apex.

Head with dense, partially concealed punctures, but with a shining impunctate space at base. Rostrum slightly longer than prothorax, moderately curved, rather stout at base and evenly decreasing to apex; punctures small but fairly distinct on the pale part, larger but almost concealed towards base. Prothorax about as long as the basal width, sides somewhat rounded in middle, base much wider than apex; punctures moderately large and dense; medio-basal impression well defined. Elytra at middle about twice the width of prothorax; strongly striate-punctate, interstices with minute punctures. Length, 2·5-2·75 mm.

♀. Differs in having the rostrum longer, thinner, more curved, and clothed only near base.

Hab.—Queensland: Mabuiag, Boigu and Cornwallis Islands (C. T. McNamara), Coen River (W. D. Dodd); Northern Territory: Darwin (W. D. Dodd and A. M. Lea).

Fairly close to *A. congestum*, but rostrum longer and more curved in female, and elytra with a seminude median space, about which the pubescence is somewhat condensed. More than half of the rostrum appears to be reddish in both sexes; *A. vertebrale*, which is also close, has elytral clothing more uniform (although leaving a seminude median space), and rostrum of both sexes much less strongly curved and darker in the female; on the present species more than half of the rostrum is reddish in both sexes. Many specimens appear to have two pale fasciae of clothing behind the seminude space, the two separated by an irregular line, where the clothing is rather sparse. On some specimens the funicle is rather deeply infuscated.

APION RIVULARE, n. sp.

Colours and clothing as described in the preceding species, except that the antennae are usually entirely dark, the abdomen is conspicuously paler and the seminude space on the elytra smaller. Length, 2·5 mm.

Hab.—Northern Territory: Roper River (N. B. Tindale); North-western Australia: Fortescue River, Derby (W. D. Dodd).

In general appearance strikingly close to the preceding species, of which perhaps it should be regarded as a variety, but differs in being consistently slightly paler, with the abdomen conspicuously paler than the sterna. Structurally the male is practically identical with that of the preceding species, but the rostrum of its female is very little longer, thinner or curved, so that the sexes are difficult to distinguish; whereas on the preceding species the rostrum of the female is decidedly longer, thinner and quite strongly curved, so that the sexes are distinguishable at a glance. Both species were taken in abundance. The rostrum of the female is about the length of that of the male of *A. vertebrale*, and much shorter than its female.

APION ORTHODOXUM, n. sp.

♂. Dull castaneous-brown, suture infuscated, apical two-thirds of rostrum (but not the tip), antennae and legs flavous, claws black. Almost evenly clothed with white pubescence.

Head with dense, partially concealed punctures. Rostrum gently curved, slightly longer than prothorax, moderately stout at base and feebly decreasing

in width to apex; with small punctures, becoming larger but partially concealed at base. Prothorax slightly shorter than the basal width, which is distinctly more than that of apex, sides moderately rounded in middle; punctures as between eyes; with a small medio-basal impression. Elytra with greatest width almost twice that of prothorax; strongly striate-punctate, the interstices with small, normally concealed punctures. Length, 2·5-2·75 mm.

♀. Differs in having the rostrum longer, thinner, more curved, and clothed only about base, instead of almost to middle.

Hab.—South Australia: Port Lincoln (A. M. Lea).

Very close to *A. anthidium* and *A. solani*, but consistently slightly darker, with the suture infuscated and the clothing slightly longer; it is about the size of the former (of which perhaps it should be regarded as a variety), and slightly larger than the latter; *A. fuscosuturale* is a decidedly smaller species, with more variegated elytra. On some of the specimens the elytral clothing is quite uniform, but on others there are two small median spots, where, owing to its being sparser than elsewhere, the derm is less obscured; the sides of the mesosternum and metasternum are more densely clothed than elsewhere.

Rhinomacerides.

AULETES CALCEATUS Pasc.

On the type of this species (from Champion Bay) the head and rostrum (except the apex), two apical joints of tarsi, and the under surface were described as black, the scutellum and suture as fuscous; the general colour being noted as "*lutescens*". I have seen no specimens apparently belonging to the species from Western Australia, north of the Swan River, nor any from that State of which the colour is not more or less distinctly reddish; in other States, however, some of the specimens could fairly be regarded as "*lutescens*"; but the black or dark parts vary considerably. Although Pascoe described the clothing as "*obsolete pubescens*", the specimens I refer to the species all have (unless abraded) a fringe of white pubescence behind a subbasal depression on the elytra, the depression, or part of it, often infuscated; the fringe is often quite distinct, but is sometimes rather feeble. The elytra were described as "*subseriatim fortiter punctulatis*"; their punctures are strong, more or less lineate in arrangement about the base, but become smaller and less regular posteriorly. Three specimens, from Victoria, are apparently close to the typical form in colour, but have the rostrum entirely dark; one of them has the pronotum slightly infuscated in the middle, and another has it deeply infuscated, but with the apex and base narrowly reddish. There are also many other slight variations from the typical form and its varieties, that are not here noted.

Var. INSULARIS Lea.—Three specimens from Tasmania (Turner's Marsh, Launceston and Waratah) belong to this variety. Two from Victoria (Diamond Creek) differ only in having the pale part of the rostrum less sharply defined.

Var. TASMANIENSIS, n. var.—Many specimens from Tasmania (St. Patrick's River, Turner's Marsh, West Tamar, Karoola, Stanley and Launceston) have the head, basal half (or less) of rostrum, scutellum, mesosternum, metasternum, and parts of two apical joints of tarsi black, the suture and sometimes a blotch about the scutellum infuscated. This variety is close to the preceding one, but the specimens have the antennae, pronotum, and abdomen entirely pale. Three specimens, from Karoola and Turner's Marsh, have the abdomen blackish at the base, but otherwise agree with the variety.

Var. ORIENTALIS, n. var.—Three specimens from Brisbane have the head, club, scutellum, a slight blotch near it, suture, and a median fascia on the pronotum moderately infuscated; and the rostrum of a dingy red, its base and tips slightly infuscated; two of them have the under surface entirely pale, the third has the metasternum somewhat darker. Four from New South Wales (Mittagong, Katoomba and Sydney) agree closely with them. On this variety the white post-scutellar fringe is traceable, but is somewhat obscure, as the other parts of the elytra are moderately clothed with white pubescence.

Var. MERIDIONALIS, n. var.—Numerous specimens from South Australia (Mount Lofty) have the whole of the upper and under surfaces, rostrum and club deeply infuscated or blackish, and usually the hind femora are infuscated in the middle. In general appearance they are close to *A. densus*, but they have the post-scutellar fringe of white hairs typical of the species. One specimen from Murray Bridge has the legs entirely black. Many others, from Mount Lofty and Adelaide, almost connect with the typical form, having the pronotum entirely pale, or with a broad transverse infuscation, and the elytra pale except for the suture and a blotch about the scutellum; several of them have the hind femora blackish in the middle.

AULETES TIBIALIS Lea.

Some specimens from Queensland (Townsville and Cairns), Torres Strait (Thursday and Dalrymple Islands) and the Northern Territory (Darwin), probably belong to this species, but differ from the type in having the legs entirely black, the antennae reddish between the first joint and the club, and the clothing sparser. They differ slightly amongst themselves in the length of the rostrum and the punctures of its sides, but the differences are probably sexual.

AULETES ATERRIMUS Lea.

Two specimens from Tasmania (Cradle Mountain and Strahan) probably belong to this species, but they differ from the types in having the prothorax slightly longer, and with denser punctures, and elytra more parallel-sided; on one of them the elytral punctures less noticeably decrease in size posteriorly, but on the other they are much as on the types.

AULETES IMITATOR Lea.

A common species in Tasmania. Two specimens, from Launceston, differ from the normal form in having the elytra of a dingy piceous-brown; another, from Hobart, has the elytra of a brighter brown, with the front femora and tibiae and the base of the other femora almost flavous.

AULETES SOBRINUS Lea.

The type of this species was probably old and somewhat faded. Seven fresh specimens from South Australia (Lucindale and Port Lincoln) appear to belong to it, but have the elytra and rostrum deep black, without metallic gloss, or with a faint brassy one. The tibiae vary from reddish to black. Two specimens have the elytra almost glabrous, but this was probably due to abrasion.

AULETES DECIPIENS Lea.

Some specimens from South Australia (Mount Lofty Ranges and Kangaroo Island), and New South Wales (Mittagong), belong to this species, but have the elytra of a brighter colour (almost castaneous) than on the types.

AULETES EUCALYPTI Lea.

The types of this species, from Western Australia, have the antennae pale, except for the club; but the species is widely distributed and some specimens from South Australia, New South Wales, Victoria, and Tasmania, have the basal joint infuscated, probably indicating that the original specimens should be regarded as varietal of *A. turbidus*.

AULETES PUNCTICOLLIS Lea.

Six specimens from South Australia (Lucindale), evidently belong to this species; two are coloured as the types, the others have the head immaculate, rostrum pale, except at the tip, and metasternum scarcely darker than the abdomen.

AULETES PILOSUS Lea.

A specimen from Tasmania (Huon River) agrees well in structure and clothing with the type of this species, but is of uniform reddish colour, except that the club and tip of rostrum are infuscated, and the claws blackish. It probably represents a variety, as it does not appear to be immature.

AULETES VARIICOLLIS Lea.

Of several fresh specimens of this species one has the head (but not the rostrum) and prothorax entirely reddish, another has the prothorax entirely reddish; and another is dark reddish-brown, in parts black, with the front parts of the femora reddish, the rest of the legs more or less infuscated.

AULETES STRIATOPUNCTATUS, n. sp.

♂. Of a dingy flavous-brown or testaceous, prothorax (except for some faint infuscations) and base of femora paler, antennae darker, rostrum blackish. Rather densely clothed with short, depressed, pale pubescence.

Head with small, crowded punctures, and with a faint interocular depression. Eyes rather large, lateral, coarsely faceted. Rostrum long (almost as long as head and prothorax combined), thin, shining, and distinctly curved, slightly dilated at base, apex and middle; with a row of small punctures on each side of a median line between base and insertion of antennae, and dense punctures on the basal half of the sides. Antennae thin, inserted slightly nearer apex than base of rostrum, first joint almost as long as second and third combined, second slightly longer and stouter than third; club loosely articulated. Prothorax about as long as wide, sides evenly rounded, disc almost flat; punctures as on head. Elytra slightly wider than widest part of prothorax, parallel-sided to beyond the middle; with rows of large punctures in thin striae, the interstices with very minute punctures. Legs moderately long, femora stout. Length (excluding rostrum), 3 mm.

♀. Differs in being paler, rostrum slightly longer, thinner, dense punctures on sides continued to a shorter distance from base, and antennae inserted slightly nearer base than apex.

Hab.—Queensland: Coen River (W. D. Dodd).

The position of the antennae differs from that of all other Australian species of the genus, and may be considered as of generic importance. The pronotum of the male is slightly infuscated in the middle, and on each side, but the infuscations are absent from the female.

AULETES SULCIBASIS, n. sp.

Black, elytra with a dark bluish gloss. With sparse dark pubescence, sloping on elytra, depressed elsewhere.

Head strongly convex between eyes, and with rather sparse but distinct punctures there. Rostrum comparatively short and broad, the length of prothorax, sides incurved to middle, with a distinct groove on basal third; with small scattered punctures. Antennae inserted about as far from eyes as from each other, second joint slightly shorter than first and third. Prothorax slightly longer than the median width, which is about equal to head across eyes, sides moderately rounded; punctures not very large or crowded. Elytra at base much wider than prothorax, and almost twice as wide slightly beyond the middle, with a rather deep subbasal depression, subsutural striae distinct to near base; punctures sparse and small. Length, 3 mm.

Hab.—Queensland: Mount Tambourine (Dr. E. W. Ferguson).

A large black species, the elytra appearing dark metallic blue in certain lights, the rostrum comparatively short and with a distinct basal groove.

AULETES INCANUS, n. sp.

Black, elytra with a faint metallic gloss. Rather densely clothed with fairly long, whitish pubescence.

Head with moderately large and fairly dense punctures. Rostrum long, thin, cylindrical, and almost straight, with a row of small punctures on each side from base to apex. Antennae thin, inserted close to base of rostrum, about twice as far from eyes as from each other. Prothorax slightly longer than the median width, sides evenly rounded, punctures as on head, but leaving a shining median line. Elytra distinctly wider than prothorax, sides very feebly dilated to beyond the middle, subsutural striae distinct to near base; punctures smaller and denser than on prothorax, and nowhere lineate in arrangement. Length, 2·25-2·5 mm.

Hab.—South Australia: Lucindale (B. A. Feuerheerdt), Port Lincoln (A. M. Lea).

A black species, with a slight metallic gloss, and with longer and paler pubescence than usual; in most lights the antennae seem entirely black, but on some examples the joints between the first and club appear as if obscurely diluted with red. The rostrum is about twice the length of the prothorax, and very feebly curved. The greatest width of the prothorax is just perceptibly nearer the base than the apex. *A. sobrinus* has somewhat similar but sparser clothing, and paler elytra, with seriate and larger punctures.

AULETES INFLATICOLLIS, n. sp.

Black, elytra with a bluish or greenish gloss. With moderately dense but dark and inconspicuous pubescence, suberect on the elytra.

Head with sharply defined, but not very large or dense punctures. Rostrum long, thin, but somewhat flattened, and slightly curved; with minute punctures, and with a feeble medio-basal groove. Antennae thin, inserted near base of rostrum, second joint stouter and shorter than third. Prothorax transverse, sides strongly rounded and widest near base; with dense and sharply defined, but not very large, punctures. Elytra much wider than base of prothorax, sides feebly dilated to beyond the middle, subsutural striae distinct to near base; punctures denser and smaller than on prothorax, and nowhere seriate in arrangement. Length, 1·75-2 mm.

Hab.—South Australia: Port Lincoln (Rev. T. Blackburn), Murray Bridge and Kangaroo Island (A. M. Lea).

A somewhat depressed species, with metallic elytra. The rostrum is longer than on *A. imitator*, being about the length of the head and prothorax combined, and the elytra have a bluish or metallic gloss although on the Kangaroo Island specimen it is more bronzy than bluish. The rostrum is not as long as in *A. aterrimus*. *A. sulcibasis* is a larger species, with very different punctures, rostrum, and base of elytra.

A specimen from Port Lincoln (A. M. Lea) appears to belong to this species, but differs from the other specimens in being larger (2·5 mm.), head impunctate in front, prothorax with a feeble median line, and elytra more dilated posteriorly.

AULETES LATIPENNIS, n. sp.

Black, antennae reddish, basal joint and club blackish. With sparse, short, dark pubescence.

Head with moderately dense, sharply defined punctures. Rostrum the length of prothorax, comparatively wide, almost straight, sides slightly incurved to middle; with crowded punctures behind antennae, and slightly in front of them, elsewhere with small and sparse ones. Antennae inserted near base of rostrum, slightly nearer each other than to eyes, second joint slightly shorter and stouter than third. Prothorax distinctly longer than wide, sides evenly rounded; punctures about as large as those on head but more crowded. Elytra short and broad, almost twice the width of base of prothorax, subsutural striae distinct to base; with rows of moderately distinct punctures on about basal half, becoming smaller and irregular posteriorly, and with small scattered punctures. Length, 2·5 mm.

Hab.—Northern Queensland (Blackburn's collection), Cairns (Dr. E. W. Ferguson).

In general appearance like *A. aterrimus*, but the rostrum shorter, wider and straighter, prothorax longer and with more crowded punctures, and the elytra wider, with sparser punctures. The pubescence is distinct only from the sides, from above the upper surface appears to be glabrous.

AULETES ORTHORRHINUS, n. sp.

Black, parts of antennae and of legs reddish. Moderately clothed with short, whitish or ashen pubescence.

Head with dense, sharply defined punctures. Rostrum not very long (slightly shorter than prothorax), thin at the base and slightly dilated to apex, straight, almost impunctate, even at base. Antennae inserted almost at base of rostrum, but almost twice as far from eyes as from each other, second joint stouter than third, but no longer. Prothorax about as long as the median width, sides rather strongly and evenly rounded; punctures much as on head. Elytra about one-fourth wider than middle of prothorax, parallel-sided to beyond the middle, with a feeble subbasal depression, sutural striae distinct to near base; punctures on basal third about as large as on pronotum but more crowded, becoming smaller posteriorly but quite sharply defined, and nowhere seriate in arrangement. Length, 2 mm.

Hab.—Queensland: Cairns (Dr. E. W. Ferguson).

A small black species, with unusually large eyes. Differs from the preceding species in having paler clothing, slightly shorter prothorax and very different elytral punctures, but the prothoracic ones are similar. *A. aterrimus* has sparser clothing, longer and thinner rostrum, and elytral punctures somewhat seriate in

arrangement. The elytra are shorter and with denser punctures than on *A. tibialis*, on which some of them are seriate near the base. On the type the joints of the antennae between the first and club are reddish, the front legs have the tibiae and the front part of the femora reddish. On a second example only the club of the antennae is dark, and all its tibiae and parts of its femora are reddish.

AULETES PSILORRHINUS, n. sp.

Black, elytra obscurely paler. Moderately clothed with white pubescence, the elytra in addition with dark setae.

Head with rather dense, sharply defined punctures. Rostrum long, about once and one-half the length of prothorax, thin, subcylindrical, and slightly curved; with a row of rather distant punctures on each side. Antennae inserted near base of rostrum, much closer to each other than to eyes. Prothorax about as long as wide, sides moderately rounded, punctures dense and somewhat coarser than on head. Elytra comparatively long, not much wider than head across eyes, with a feeble subbasal depression; with closely placed rows of large punctures, becoming somewhat smaller and more irregular posteriorly. Length, 1·75 mm.

Hab.—South Australia: Murray Bridge (A. M. Lea), unique.

A narrow black species (the elytra blackish), with white pubescence and unusually coarse punctures It is smaller, narrower and darker than *A. densus*, and with longer and less straight rostrum. In colour and general appearance it is close to *A. sobrinus*, on a reduced scale, but the elytral punctures are seriate in arrangement almost throughout, although from some directions this is not very conspicuous. The punctures, especially on the elytra, are much coarser than on *A. imitator*. The setae on the elytra are almost upright, but, except the marginal ones, are distinct only from the sides. The subsutural striae are somewhat obscured by the punctures.

AULETES LINEATOPUNCTATUS, n. sp.

Black, elytra and parts of legs piceous-brown, antennae with joints between the first and club almost flavous. Clothed with moderately dense, ashen pubescence, the elytra, in addition, with sparse, suberect setae.

Head with dense, sharply defined punctures. Rostrum thin, slightly longer than prothorax, subcylindrical, slightly curved, with a short mediobasal groove; with a row of small punctures on each side of upper surface. Antennae unusually thin, inserted at about basal fifth of rostrum, and about twice as far from the eyes as from each other. Prothorax slightly longer than wide, sides gently rounded; punctures much as on head. Elytra rather long, much wider than base of prothorax; with rows of large punctures, much wider than interstices, but becoming smaller posteriorly. Length, 1·75 mm.

Hab.—Northern Territory: Groote Eylandt (N. B. Tindale), unique.

In general appearance close to the preceding species, but rostrum thinner, antennae decidedly longer and thinner, and elytral punctures larger and more conspicuously lineate in arrangement. The elytra are not depressed near the base, and the sutural striae are ill-defined.

AULETES CASTOR, n. sp.

Black, shining. Sparsely and finely pubescent.

Head with distinct but irregularly distributed punctures, and with a short groove continued on to base of rostrum. Rostrum long (as long as head and

prothorax combined), thin, cylindrical, almost straight; with minute punctures. Antennae inserted near base of rostrum, about twice as far from eyes as from each other, second joint stouter and slightly shorter than third. Prothorax about as long as the median width, sides rather strongly rounded and widest slightly nearer base than apex; with fairly dense, sharply defined punctures. Elytra much wider than prothorax, sides moderately dilated to beyond the middle, subsutural striae distinct to near base; punctures not very dense. Length, 1·5 mm.

Hab.—South Australia: Lucindale (B. A. Feuerheerdt).

A small species, smaller than *A. imitator*, rostrum considerably longer in proportion, and elytra with much finer punctures; smaller also than *A. aterrimus*, elytra narrower and with finer non-seriate punctures. The elytral punctures are small and nowhere dense or sharply defined, in some lights a few of them appear subseriately arranged near the inner base.

Auletes pollux, n. sp.

Black, shining. With very short, dark pubescence.

Head with fairly numerous sharply defined punctures, but almost impunctate in front, where there is a small median impression. Rostrum scarcely longer than prothorax, thin, cylindrical, slightly but distinctly curved, highly polished and almost impunctate. Antennae inserted almost at base of rostrum. Prothorax about as long as the greatest width, which is slightly nearer base than apex, sides rounded; punctures rather dense and sharply defined. Elytra distinctly wider than prothorax, sides feebly dilated to beyond the middle, subsutural striae distinct; punctures on basal third almost as large as on prothorax, but not quite as dense, becoming smaller posteriorly, and nowhere seriate in arrangement. Length, 1·5 mm.

Hab.—Queensland: Mount Tambourine (A. M. Lea).

About the size of the preceding species, but elytra narrower, their punctures denser and stronger, and the rostrum shorter and more distinctly curved. It is smaller than *A. imitator*, with a shorter rostrum; smaller and narrower than *A. aterrimus*, with the rostrum shorter and less curved.

Auletes anthracinus, n. sp.

Black, shining. Moderately clothed with dark pubescence.

Head with fairly dense, sharply defined punctures. Rostrum straight, about the length of the prothorax in the male, slightly longer in the female, comparatively wide and slightly dilated to apex, with a narrow mediobasal groove continued on to head; with a fairly distinct row of punctures on each side, and small ones elsewhere. Antennae inserted near base of rostrum, more distant from eyes than from each other, second joint stouter and shorter than third. Prothorax slightly shorter than the median width, sides strongly rounded; punctures dense and rather coarse. Elytra about one-fourth wider than widest part of prothorax, subsutural striae distinct, with a feeble subbasal depression; punctures smaller and less sharply defined than on prothorax, becoming smaller posteriorly, and in places feebly subseriately arranged. Length, 2-3 mm.

Hab.—South Australia: Port Lincoln and Petersburg (Rev. T. Blackburn), Mount Lofty Ranges (N. B. Tindale and A. M. Lea), Gawler (Lea).

With outlines much as on *A. tibialis* but clothing sparser, elytra with sparser punctures, and legs entirely dark. Close also to *A. imitator*, and with similar rostrum and prothoracic punctures, but rather more robust, and elytral punctures somewhat seriate in arrangement on the basal third near the suture. On several

specimens the antennae between the first joint and the legs, or the front tibiae only, are obscurely diluted with red, but these specimens at the first glance appear just as dark as the others.

Some specimens from Parachilna (E. L. Savage), Mount Lofty and Murray Bridge (Lea), probably belong to this species, but they all have the elytra somewhat narrower.

AULETES OBSCURUS, n. sp.

Black; elytra, legs and antennae between the first joint and the club, more or less obscurely piceous-brown. Rather densely clothed with short, whitish pubescence.

Head with dense punctures of moderate size, but partially concealed by clothing. Rostrum long, thin, cylindrical, and almost straight; behind antennae with crowded punctures, in front of them shining, and with a row of small punctures on each side. Antennae inserted near base of rostrum. Prothorax slightly shorter than the median width, sides rather strongly rounded; punctures crowded and slightly larger than on head. Elytra comparatively narrow, not much wider than widest part of prothorax, parallel-sided to beyond the middle, subsutural striae well defined; punctures dense, smaller than on prothorax, but fairly sharply defined, and nowhere seriate in arrangement. Length, 1·75-2 mm.

Hab.—South Australia: Port Lincoln (Rev. T. Blackburn and A. M. Lea), Murray Bridge (Lea), Goolwa.

A small, dingy species; the elytra are usually piceous-brown (sometimes almost black), but vary to almost castaneous, although never brightly coloured; the front legs (except the tarsi) are sometimes of a rather dingy flavous, and the base and apex of prothorax are sometimes narrowly pale. A dark specimen of *A. variipennis* is somewhat similarly coloured, but its elytra are much wider in proportion, and the punctures are decidedly coarser. *A. imitator* is about the same size, but is deep black and more sparsely clothed. The colours of some specimens are much as those of *A. psilorrhinus*, but the elytral punctures are very different. In the female the rostrum is about as long as the head and prothorax combined, in the male it is slightly shorter.

AULETES RHYPAROCHROMUS, n. sp.

Of a dingy piceous-brown, base and apex of prothorax and elytra slightly paler, antennae between first joint and club, and legs (except tarsi) still paler. Moderately clothed with depressed, whitish pubescence.

Head with dense, sharply defined punctures. Rostrum about as long as head and prothorax combined, thin, cylindrical, slightly but distinctly curved; punctures fairly dense behind antennae, but inconspicuous elsewhere. Antennae inserted near base of rostrum, second joint stouter and slightly shorter than third. Prothorax about as long as the median width, sides strongly rounded, punctures dense and rather coarse. Elytra comparatively short, much wider than prothorax, sides feebly dilated to beyond the middle, subsutural striae fairly distinct to near the base; punctures dense and well defined, but smaller than on prothorax, and nowhere seriate in arrangement. Length, 1·5-1·75 mm.

Hab.—South Australia: Port Lincoln (Rev. T. Blackburn).

In general appearance close to the preceding species, but rostrum thinner, somewhat curved, and elytra wider in proportion. A specimen from Murray Bridge (A. M. Lea), evidently belongs to the species, but appears to be immature, as its elytra and parts of the legs are pale flavous.

AULETES LATERIROSTRIS, n. sp.

Flavo-castaneous or castaneous; head, rostrum (wholly or in part), club (and sometimes the basal joint) of antennae, prothorax (except base and apex), scutellum, metasternum, and parts of tarsi black or infuscated. Clothed with whitish pubescence, the elytra, in addition, with semierect setae.

Head with dense and sharply defined but not very large punctures. Rostrum straight, about the length of prothorax, comparatively wide, sides incurved to middle; behind antennae with a median groove and crowded punctures, in front of them with a conspicuous row of punctures on each side. Antennae inserted fairly close to base of rostrum. Prothorax distinctly longer than wide, sides gently and evenly rounded; punctures much as on head. Elytra about twice the width of base of prothorax, parallel-sided to near apex, with a shallow subbasal depression; subsutural striae distinct; with almost regular rows of large punctures, the interstices with dense and small ones. Length, 2-2·5 mm.

Hab.—Northern Queensland (Blackburn's collection), Cairns district (Dr. E. W. Ferguson and A. M. Lea), Cedar Creek, Malanda (Dr. E. Mjöberg), Blackall Range (Mjöberg and Lea); New South Wales: Dorrigo (W. Heron), Sydney (H. W. Brown).

A very distinct but rather dingy species, with a faint post-scutellar fringe, approaching that of *A. calceatus*, but rostrum with a conspicuous row of punctures on each side, the punctures so large and close together as almost to form a furrow on each side. The suture varies from feebly to deeply infuscated. The specimen, from Cairns, has the prothorax and rostrum entirely pale. The specimen from Sydney is darker than usual, and has the elytral pubescence more conspicuous on the basal third, and forming feeble triangles on the sides and apex; its rostrum, however, is normal.

AULETES POSTSCUTELLARIS, n. sp.

Castaneous; head, scutellum, suture and parts of tarsi black, club, metasternum, and a blotch about scutellum infuscated. Irregularly clothed with white and ashen pubescence.

Head with crowded and sharply defined but not very large punctures. Rostrum long (about as long as head and prothorax combined), rather thin in middle, but somewhat dilated to base and apex, and feebly curved; behind antennae with a narrow median groove and dense punctures, in front of them with a distinct row of punctures on each side, but becoming small in front. Antennae inserted at about basal fifth, almost thrice as far from eyes as from each other. Prothorax slightly longer than the greatest width, which is slightly beyond the middle, sides strongly rounded; punctures much as on head. Elytra almost twice as wide as the base of prothorax, parallel-sided to beyond the middle, subsutural striae distinct; with closely placed rows of large punctures, becoming somewhat smaller posteriorly. Length, 3-3·25 mm.

Hab.—Northern Queensland (Blackburn's collection), Cedar Creek (Dr. E. Mjöberg).

With a conspicuous patch of whitish clothing in the subbasal depression of the elytra, suggestive of *A. calceatus*, but the patch larger and more conspicuous, the rostrum longer and with a row of punctures on each side, the prothoracic punctures denser, and the elytral punctures seriately arranged throughout, although they are so close together that from some directions the rows are not evident. The white pubescence is also distinct about the apex of the elytra, and on the metasternum. The preceding species is smaller, has a shorter and straighter

rostrum, with the punctures on each side of it larger and more conspicuous, and the *calceatus*-like post-scutellar fringe less distinct. On one specimen the rostrum is almost black, and the pronotum is widely infuscated in the middle, on two others the rostrum is black (except the tip), and the infuscation on the pronotum is very faint.

AULETES ERYTHRODERES, n. sp.

Black; prothorax and front femora and tibiae red. Rather sparsely clothed with dark, inconspicuous pubescence, the elytra, in addition, with suberect setae.

Head with fairly numerous, sharply defined punctures, becoming sparse in front. Rostrum slightly shorter than head and prothorax combined, rather thin but not cylindrical, almost straight, with a narrow subbasal impression; punctures inconspicuous. Antennae inserted near base of rostrum. Prothorax transverse, sides dilated to near base, and then suddenly narrowed to base itself, a narrowly impressed line across base; punctures rather large and numerous, but not crowded. Elytra beyond the middle about twice the width of base of prothorax; with rather large, rugose punctures, seriate in arrangement towards the base, but smaller and less regular towards the apex and sides. Length, 2 mm.

Hab.—Victoria: Sea Lake (J. C. Goudie).

Approaching *A. insignis*, but slightly smaller, punctures coarser and head black. A specimen, from South Australia, in the Blackburn collection, is in bad condition, but agrees with the type in colour, except that the middle legs are also partly red.

AULETES FLAVIPENNIS, n. sp.

Reddish-flavous, elytra flavous; club and basal joint of antennae, scutellum, metasternum, and parts of tarsi black or infuscated. Moderately clothed with white pubescence, and with suberect setae, the pubescence very sparse on elytra.

Head with dense and sharply defined, but rather small punctures, becoming sparser and smaller towards base. Rostrum as long as head and prothorax combined, thin, cylindrical, almost straight; with a narrow impression and rather dense punctures behind antennae, with a row of rather small punctures on each side in front of them. Antennae inserted near base of rostrum, second joint stouter and slightly shorter than third. Prothorax slightly longer than the greatest width, sides moderately and almost evenly rounded; punctures crowded and somewhat coarser than those on head. Elytra rather long, feebly dilated to beyond the middle, where the width is twice that of the prothorax, subsutural striae distinct throughout; punctures small and sparse. Length, 2·5 mm.

Hab.—South Australia: Kangaroo Island, Port Lincoln (A. M. Lea).

The shining and sparsely clothed elytra, with sparse and small punctures, readily distinguish from all other Australian species of the genus. On the Port Lincoln specimen, in certain lights, there appear to be faint vestiges of striation, with fairly large punctures, but these are entirely due to "waterlogging," the only impressed striae are sutural and marginal; it also has a shining median line on the pronotum, of which there is no trace on the type. On both specimens the suture and abdomen are slightly infuscated. On the Kangaroo Island one the rostrum and parts of the front and hind femora are deeply infuscated, on the other the rostrum (except the tip) is no darker than the head, and the femoral infuscations are slight.

AULETES MELANOSTETHUS, n. sp.

Flavous or flavo-castaneous; head, rostrum, club, scutellum, metasternum and parts of tarsi black; suture, abdomen, and basal joint of antennae infuscated. Moderately clothed with short, whitish pubescence, and with suberect, darker setae.

Head with sharply defined and fairly dense punctures. Rostrum slightly longer than prothorax, almost straight, not very thin, sides slightly incurved to middle; with a narrow mediobasal groove, continued on to front of head, and with a row of small punctures on each side. Prothorax about as long as the greatest width (fairly close to base), sides moderately rounded, near base narrowly constricted; punctures dense, and slightly larger than on head. Elytra about one-third wider than widest part of prothorax, subsutural striae distinct to near base; punctures sparse and small, except for some large seriate ones in and about a shallow subbasal depression. Length, 2·5-2·75 mm.

Hab.—South Australia: Port Lincoln (Rev. T. Blackburn).

At first glance fairly close to the preceding species, but elytra with some large seriate punctures, and rostrum decidedly shorter and thinner. It is larger than *A. eucalypti*, with wider rostrum, sparser elytral punctures (coarser about base), and longer clothing. One specimen has the prothorax and elytra of an almost uniform bright castaneous, but two others are somewhat paler, with the elytra slightly paler than the prothorax.

AULETES CARINICEPS, n. sp.

Of a rather pale reddish-castaneous; tip of rostrum, club, scutellum, suture, metasternum and claws black or infuscated. Rather densely clothed with whitish pubescence, more conspicuous on metasternum than elsewhere.

Head with crowded punctures, and with a shining median carina. Rostrum slightly longer than prothorax, thin and cylindrical to near apex, where it is slightly flattened, and almost straight; with a feeble medio-basal impression; in front of antennae with a row of small punctures on each side. Antennae inserted almost at base of rostrum, about thrice as far from eyes as from each other. Prothorax slightly longer than the median width, sides moderately rounded; punctures crowded and slightly larger than on head. Elytra rather long, beyond middle almost twice as wide as base of prothorax, with a shallow subbasal depression, subsutural striae distinct to near base; punctures dense, smaller than on prothorax, becoming smaller posteriorly and nowhere seriate in arrangement. Length, 2·75 mm.

Hab.—Queensland: Cairns district (A. M. Lea), unique.

The head has a short but distinct carina, a character apparently unique in the Australian species of the genus. There appears to be a feeble dark blotch just beyond the scutellum, and the pubescence there is directed outwards, instead of lengthwise, so as to be somewhat suggestive of *A. calceatus*, but the punctures are much denser, and without the least trace of lineate arrangement, much as on *A. suturalis*, *inconstans* and *variicollis*. There are some suberect setae on the elytra, but they are so short that even from the sides they are inconspicuous.

AULETES LEUCOTRICHUS, n. sp.

Black, base and apex of prothorax, elytra (a darker blotch about scutellum) abdomen and legs of a dingy piceous-brown, tibiae and antennae, between the first joint and the club, paler. Moderately clothed with depressed, white pubescence, in addition with sparse, suberect setae.

Head with dense, partially concealed punctures. Rostrum about as long as head and prothorax combined, distinctly curved, rather thin but somewhat flattened, sides gently incurved to middle; with crowded punctures behind antennae, sides with irregular ones in front of them. Antennae thin, inserted about one-fourth from base of rostrum, fully thrice as far from eyes as from each other. Prothorax slightly longer than wide, sides evenly rounded; punctures crowded and rather coarse. Elytra rather long, parallel-sided to near apex, almost twice as wide as base of prothorax, with a shallow subbasal depression; with dense punctures, slightly larger than on prothorax about base, but becoming slightly smaller posteriorly. Length, 2·5 mm.

Hab.—Tasmania: Hobart (A. M. Lea), unique.

With the general appearance of *A. pilosus*, and with very similar punctures, but rostrum longer, thinner and distinctly curved, and antennae longer and thinner. The proportions of the rostrum and antennae are much as in *A. melaleucae*, but the punctures are decidedly coarser, and the general colour is darker. It is still closer in appearance to *A. sobrinus*, but the rostrum is more noticeably curved, and the elytral clothing is shorter and denser. The second joint of the antennae is slightly stouter than the third and quite as long. From most directions the elytral punctures seem to be crowded and irregular, but from others they may be seen to be in closely set rows.

Five specimens, from Adventure Bay on Bruni Island, sent by M. Albert Bovie, of Brussels, belong to this species. One, a male, agrees well with the type, except that the prothorax is entirely black. The others are females, and have the rostrum somewhat longer, they have the femora infuscated only in the middle, the base and apex of prothorax more conspicuously reddish, and the elytra paler (except about the suture and scutellum), they also have in the subbasal depression a distinct *calceatus*-like fringe (this is hardly evident on the males); their general appearance is much like that of *A. c. meridionalis*, but the distinctly curved rostrum is at once distinctive from *calceatus* and its allies. The rostrum, instead of being grooved in the middle of the base, as on most species, is ridged there, owing to the scrobes having their upper margins not concealed.

CAR CONDENSATUS Blackb.

All the specimens I have seen of this species are from South Australia, and are mostly in poor condition. A specimen recently taken at Parachilna, however, is in perfect condition. Its clothing is mostly white, but there is a conspicuous yellow patch on the inner side piece of the mesosternum, another on the shoulder, and the scutellum is similarly clothed; the apical slope of the elytra is clothed with stramineous pubescence, but its summit is crowned with an irregular black fascia.

CAR INTERMEDIUS, n. sp.

Of a rather bright red, under surface blackish. Moderately clothed with stramineous or ochreous and white pubescence, dense and snowy on the scutellum; the elytra in addition with semierect, short, inconspicuous setae.

Head with fairly dense, sharply defined punctures of moderate size. Rostrum curved, about the length of prothorax, rather stout at base, feebly diminishing in width to apex, with the sides slightly compressed; punctures behind antennae almost as on head, very sparse and minute in front of them. Antennae thin, inserted about one-fourth from base of rostrum. Prothorax about as long as the basal width, sides gently rounded from middle to apex and almost parallel on basal half, with sharply defined, fairly large, and numerous but not crowded

punctures. Elytra rather short, much wider than prothorax, sides rounded from near base; with regular rows of large, angular punctures, the interstices with dense and small, partially concealed punctures. Legs rather short and stout. Length, 3 mm.

Hab.—Queensland: Bribie Island (A. M. Lea), unique.

Intermediate in size between *C. pini* and *C. condensatus*. In addition distinguished from the former in having larger eyes, elytra differently variegated, and under surface darker; from the latter in the differently variegated elytra, darker under surface, and snowy clothing of scutellum. The eyes are much as on the latter species, but the rostrum is slightly shorter than its male. The clothing of the type is in perfect condition, the ochreous pubescence is not very dense on the head, base of rostrum, and pronotum, it is replaced by whitish on an ill-defined triangular basal space on elytra, beyond which it forms a conspicuous feebly defined V, between which and the apex it appears slightly mottled; it is rather dense on the sides of the mesosternum and metasternum, on the rest of the under surface it is white.

RHINOMACER AUSTRALIAE, n. sp.

Castaneous; sides of prothorax, parts of under surface and middle of femora infuscated, elytra with numerous small spots. Rather densely clothed with depressed, whitish pubescence.

Head wide and rather strongly convex, with crowded and small punctures. Eyes large, occupying the sides from base to base of rostrum, facets coarse. Rostrum (excluding jaws) about the length of prothorax, rather wide and slightly curved. Antennae thin, first joint hardly larger than second, three apical ones forming a loose club. Prothorax distinctly longer than wide, sides moderately and evenly rounded; punctures much as on head. Elytra elongate, almost parallel-sided to beyond the middle, where the width is almost twice that of the prothorax; with regular rows of large punctures, becoming smaller posteriorly, the interstices with dense and minute punctures. Length, 3-4 mm.

Hab.—Northern Queensland (Blackburn's collection).

Structurally fairly close to the British *R. attelaboides*, and the American *R. elongatus*, but eyes larger, and with larger facets, etc. It is the first true species of the genus to be recorded from Australia. The dark spots on the elytra are not very sharply defined, and are obscured by pubescence; on the type nine of them are arranged to form an irregular circle occupying the median third. The type is certainly a female (its ovipositor is protruding) and has the rostrum with three conspicuous costae from base to between insertion of antennae, these inserted close behind the base of prominent jaws, the apical segment of its abdomen has a conspicuous fovea; on a second specimen, a male, the costae are much less conspicuous and there appear to be small intermediate ones (probably due to rows of punctures), the jaws are less prominent, the antennae are inserted further from their bases, and the apical segment of the abdomen is flattened in the middle.

GASTEROMYCETES OF AUSTRALASIA.

V. The Genus Calvatia.

By G. H. Cunningham, Government Mycologist, Department of Agriculture, Wellington, N.Z.

(Plates xxiii-xxiv.)

[Read 28th July, 1926.]

Species of this genus have been recorded from every continental area. They grow for the most part in pastures and sandy regions. In the genus are found the largest known "puff-balls", and in one species plants have been recorded as attaining a circumference of 135 cm.

Until the appearance of Morgan's paper (1890) species were placed under *Lycoperdon* or *Bovista*, according to whether a well-defined sterile base was present or absent. Morgan, however, clearly defined the genus as being separated from *Lycoperdon* by the method of dehiscence. In *Lycoperdon* the plant is perforated apically by a single aperture (stoma) through which the spores escape. In *Calvatia* this aperture is wanting, dehiscence being effected by the irregular breaking away of the upper portion of the peridium. Notwithstanding the fact that Morgan so defined *Calvatia* as to make separation from *Lycoperdon* a relatively simple matter, the genus has not yet become generally recognized in Britain and Europe, for it is usual to find species of *Calvatia* referred to *Lycoperdon* in the more recent systematic publications. When Morgan's classification is followed, confusion between the two genera is likely to arise with only two species, *Lycoperdon depressum* Bon. and *L. subpratense* Lloyd; for with these species an apical stoma appears as in other species of *Lycoperdon*, but this is followed by the breaking away of the greater part of the apical portion of the peridium, consequently weathered plants may quite readily be placed under *Calvatia*. As it is usual to obtain both mature and immature plants in the same collection, no difficulty in placing these species should arise, for the stoma is noticeable in plants which have just reached maturity.

Structure of the Mature Plant.

If plants are examined before dehiscence has commenced they will be seen to consist of a well-defined peridium, enclosing the gleba and (usually) a sterile base, which occupies the lower portion of the plant.

The peridium consists of two distinct tissues, an outer exoperidium, and an inner endoperidium. The exoperidium varies in its appearance according to the species. It is best seen in plants before the gleba has matured, appearing then as a tomentose layer, approximately 1 mm. thick. It is definitely pseudoparenchymatous, and exteriorly may be tomentose, floccose, or furfuraceous. It is often fissured, when it is said to be areolate.

The endoperidium is usually quite thin, smooth and brittle, but may be membranous or papyraceous. It is composed of thick-walled, intricately interwoven, septate hyphae. At maturity it flakes away from the apical portion of the

plant, but usually persists basally, especially on the exterior of the sterile base, when the latter is present. The sterile base varies considerably in its structure according to the species. In *Calvatia caelata* and *C. lilacina* it is separated from the gleba by a prominent diaphragm, composed of the same tissue as the endoperidium; in *C. gigantea* and *C. candida* this structure is absent, the gleba then merging almost imperceptibly with the sterile base.

In the two former species, the base is composed of a definite cellular tissue, the cells being distinct and large enough to be seen without magnification. In the two latter species, the tissue does not appear cellular, but is composed of intricately interwoven hyphae of the same nature as the capillitium threads; thus it is frequently a difficult matter to determine where the gleba ceases and the base commences. In mature plants the gleba becomes a deeper colour owing to maturation of the spores, consequently the point of separation of the gleba from the sterile base is then noticeable. This non-cellular tissue of the sterile base of the two latter species is here termed compact, to differentiate it from the cellular base of the other species.

The capillitium consists of very numerous, sparingly branched, septate, thick-walled hyphae. These arise from the inner walls of the endoperidium, and in those species in which a diaphragm is wanting, from the hyphae of the sterile base.

In two species, *C. lilacina* and *C. caelata*, the capillitium threads usually break up in the mature plant into numerous small lengths; consequently the whole gleba becomes pulverulent, and is soon dissipated. In the other species, this breaking up of the threads does not occur to the same extent, consequently the gleba persists often for one or more seasons; and indeed, one occasionally meets with the more or less intact glebal mass of *C. gigantea* from which the peridium and scanty sterile base has completely fallen away.

The spores are coloured, usually globose, and may be smooth (*C. caelata*), finely verruculose (*C. gigantea*, *C. candida*), or strongly verrucose (*C. lilacina*). Frequently portion of the sterigma remains attached to the spore, a condition here termed apiculate.

I am indebted to Dr. J. B. Cleland, Adelaide, for the loan of all specimens of this genus in his herbarium; and to Mr. H. Drake, Biological Laboratory, for photographs of the different species.

CALVATIA Fries.

Summa Veget. Scand., 1849, 442, *p.p.*; emend.—Morgan, *Journ. Cin. Soc. Nat. Hist.*, 12, 1890, 165.

Peridium subglobose to pyriform, frequently with a well-developed rooting base; of two layers, an outer exoperidium which may be warted, spinose, furfuraceous, granular or smooth, and flakes away in irregular fragments; and an inner endoperidium which is thin, papyraceous or membranous, and flakes away irregularly from the apex, but persists towards the base; sterile base present, well developed or scanty.

Gleba coloured, of capillitium and spores; capillitium threads long, equal, sparingly branched, septate or continuous, attached to the inner walls of the endoperidium. Spores globose or shortly elliptical, continuous, coloured, rough or smooth.

Habitat.—Solitary or in small groups on the ground in pastures, sand-dunes or outskirts of the forest.

Distribution.—Britain; Europe; Asia; North and South America; India; Africa; Australia; New Zealand.

A small genus of about 8 species, containing most of the largest "puff-balls". Four species are present in Australasia, all being of wide distribution. The genus is separated from *Lycoperdon* solely by its means of dehiscence, which is effected by the irregular breaking away of the upper part of the peridium, and not by a definite apical stoma, as is present in *Lycoperdon*.

Key to the Species.

Diaphragm present.
- Spores smooth .. .. 1. *C. caelata.*
- Spores verrucose .. .. 2. *C. lilacina.*

Diaphragm absent.
- Plants large, exoperidium smooth, leathery .. .. 3. *C. gigantea.*
- Plants small, exoperidium furfuraceous .. .. 4. *C. candida.*

1. CALVATIA CAELATA (Bull.) Morgan. Plate xxiv, fig. 3.

Lycoperdon caelatum Bull., *Champ.*, 1, 1809, 156.—*L. Fontanesii* Dur. et Mont., *Fl. Alger.*, 1, 1849, 381.—*L. favosum* Bon., *Bot. Zeit.*, 15, 1857, 595.—*L. Sinclairii* Berk. in Herb.; Mass, *Jour. Roy. Micr. Soc.*, 1887, 716.—*Calvatia caelata* (Bull.) Morgan, *Journ. Cin. Soc. Nat. Hist.*, 12, 1890, 169.—*C. Fontanesii* (D. et M.) Lloyd, *Lyc. Aus.*, 1905, 36.—*C. favosum* (Bon.) Lloyd, *l.c.*—*C. Sinclairii* (Berk.) Lloyd, *l.c.*, p. 37.

Peridium 5-10 cm. diam., depressed-globose or subpyriform, tapering abruptly into a well-developed, crenulate, stem-like rooting base; exoperidium at first white, becoming pallid olivaceous, areolate, floccose, areolae more conspicuous basally; endoperidium brown, fragile, breaking away in irregular flakes from the apical portion. Sterile base well developed, persistent, separated from the gleba by a well-defined diaphragm, forming the lower third of the peridium, distinctly cellular throughout.

Gleba at first yellowish, becoming olivaceous; at first compact, becoming pulverulent; capillitium threads very long and flexuous, sparsely branched, septate, olivaceous. Spores globose, 4-5 μ diam., frequently apiculate; epispore olivaceous, perfectly smooth.

Habitat.—Solitary on the ground, frequent on sand-dunes near the sea coast.

Distribution.—Britain; Europe; North America; Algeria; Australia; New Zealand.

Queenstown, Otago, May, 1920, J. B. Cleland; **Otaki, Wellington, Nov., 1924, E. H. Atkinson.

I have not seen Australian specimens. The plant is characterized by the areolate peridium, smooth spores, prominent diaphragm and large, cellular base. Miss Wakefield has kindly examined the type of *Lycoperdon Sinclairii* at Kew. She states the specimen is an old one, sterile base only, and is quite smooth externally. She believes the spores and capillitium could be those of *C. caelata*. Consequently I have considered it a synonym of this species.

2. CALVATIA LILACINA (Berk. et Mont.) Lloyd. Plate xxiii, fig. 1.

Bovista lilacina Berk. et Mont., in Hook. *Jour. Bot.*, 4, 1845, 62.—*Lycoperdon novae-zelandiae* Lev., *Ann. Sci. Nat.*, ser. 3, vol. 5, 1846, 164.—*L. lilacinum* (B. et

** Specimens in my herbarium.

M.) Mass., *Jour. Roy. Micr. Soc.*, 1887, 706.—*Calvatia cyathiformis* (Bosc.) Morg., *Jour. Cin. Soc. Nat. Hist.*, 12, 1890, 168.—*C. lilacina* (Berk. et Mont.) Lloyd, *Lyc. Aus.*, 1905, 35.

Peridium up to 15 cm. diam., subglobose to subpyriform, tapering abruptly into a large, well developed, strongly crenulate rooting base; exoperidium smooth or more frequently floccose, cream to bay-brown, often areolate, thin, fragile, fugacious; endoperidium brown, thin, fragile, flaking away irregularly from the apical portion. Sterile base well developed, persistent, cellular at the periphery, hemi-compact within, separated from the gleba by a prominent diaphragm. Gleba some shade of purple, sometimes with a greyish tinge, at first compact, soon pulverulent; capillitium threads long, branched, septate, equal, pallid olivaceous. Spores globose, 5·5-7·5 μ diam., occasionally apiculate; epispore violaceous, verrucose.

Habitat.—Solitary on the ground, especially in sandy areas.

Distribution.—Southern Europe; North America; South Africa; Australia; New Zealand.

South Australia: *Locality unknown, F. R. Zeitz (2 collections); *Adelaide, Jan., 1924.

New Zealand: **Weraroa, Wellington, Oct., 1922, G.H.C.; **Mar., 1925, J. C. Neill; **Dunedin, Sept., 1922, Miss H. K. Dalrymple. **Otaki Beach, Wellington, Nov., 1924, E. H. Atkinson.

Characterized by the prominent sterile base, conspicuous diaphragm, and large, verrucose spores. The peridium and gleba are fragile, consequently the sterile base is often the only portion of the plant collected; nevertheless even this can be determined readily, owing to its structure. It is liable to confusion only with *C. caelata*, but may be separated by its peculiar, partly compact, partly cellular structure.

The peridium is usually stated to be smooth externally, but this is by no means a constant feature; on the contrary, in New Zealand, collections frequently show the exterior to be floccose and often areolate, sometimes so closely approaching *C. caelata* as to make identification difficult, but the verrucose spores serve to separate it.

Hollos (1904, p. 163) gives *Lycoperdon fragile* Vitt. as a synonym of *C. lilacina*. If his statement is correct, then the former name must replace the latter, for it has priority, being published in 1842.

8. Calvatia gigantea (Persoon), n. comb. Plate xxiii, fig. 2.

Lycoperdon giganteum Batsch ex Pers., *Syn. Meth. Fung.*, 1801, 140.—*Bovista gigantea* (Pers.) Nees, *Syst. Pilze*, 1817, 34.—*Lycoperdon Bovista* Fr., *Syst. Myc.*, 3, 1829, 29.—*Calvatia maxima* (Schaeff.) Morg., *Journ. Cin. Soc. Nat. Hist.*, 12, 1890, 166.—*C. gigantea* (Batsch) Lloyd, *Myc. Notes*, 1904, 166.—*C. primitiva* Lloyd, *Lyc. Aus.*, 1905, 36.

Peridium subglobose, up to 40 cm. diam., sessile, with a cord-like rooting base; exoperidium smooth, finely tomentose, closely resembling chamois leather, fragile, cream or yellowish, fugacious; endoperidium brown, thin, fragile, flaking away irregularly. Sterile base scanty and poorly developed, compact, frequently wanting, diaphragm absent.

* An asterisk indicates that the collection in question is in the herbarium of Dr. J. B. Cleland, Adelaide; and where the collection is preceded by an asterisk, but no collector given, it signifies that the collection was made by Dr. Cleland himself.

Gleba yellowish, becoming olivaceous, hemi-compact; capillitium threads long, sparingly branched, septate, olivaceous. Spores globose, 4·5·5 μ diam., occasionally apiculate; epispore olivaceous, verruculose.

Habitat.—Solitary on the ground in pastures.

Distribution.—Britain; Europe; North America; Australia; New Zealand.

New Zealand: **New Plymouth, W. W. Smith, Dec., 1923; **Weraroa, Wellington, Mar., 1925, J. C. Neill; **Canterbury, Jan., 1926, J. C. Neill.

The large size, leathery peridium and absence of a well-developed sterile base characterize the species. The spores are usually stated to be smooth, but are distinctly verruculose under the oil immersion. This is the commonest species in New Zealand, and may regularly be found during the spring and autumn months in certain pastures in the lowland areas.

4. CALVATIA CANDIDA (Rostk.) Hollos. Plate xxiv, figs. 4, 5.

Langermannia candida Rostk., in Sturm. *Deutsch. Fl.*, Bd. 3, Heft 18, 1837, 25.—*Lycoperdon candidum* (Rostk.) Bon., in Sacc. *Syll. Fung.*, 7, 1888, 483.—*Bovista tunicata* Bon., *Bot. Zeit.*, 15, 1857, 597.—*B. olivacea* Cke. et Mass., *Jour. Bot.*, 26, 1888, 133.—*Calvatia candida* (Rostk.) Hollos, *Term. Fuez.*, 25, 1902, 112.—*Calvatia olivacea* (C. et M.) Lloyd, *Lyc. Aus.*, 1905, 37.

Peridium up to 7 cm. diam., subglobose to pyriform, base frequently crenulate, tapering abruptly into a strongly developed, white, cord-like rooting base; exoperidium thin, furfuraceous, ochraceous, frequently areolate, fugacious; endoperidium thin, papyraceous, ochraceous or chestnut-brown, flaking away irregularly from the apex. Sterile base usually well developed, sometimes scanty, compact, yellowish, diaphragm absent.

Gleba pallid olivaceous, hemi-compact; capillitium threads sparingly branched, sparsely septate, equal, olivaceous. Spores globose, 4·5·5 μ diam., frequently apiculate; epispore olivaceous, finely and sparsely verruculose.

Habitat.—On the ground in small groups.

Distribution.—Europe; Australia.

South Australia: *Monarto South, Sept., 1920; *Adelaide, 1921; *Beaumont, Adelaide, May, 1922; *Kinchina, Apl., 1924, Miss Machlin; *Kinchina, July, 1923 (2 coll.); *F. R. Zeitz coll.

Victoria: Dimboola, F. M. Reader, Herb. Vic. Dept. Agr.

Judging from the specimens in Dr. Cleland's collection, this appears to be the most abundant species of the genus present in Australia. It is characterized by the usually well developed, compact, sterile base, prominent rooting base, furfuraceous, thin exoperidium, verruculose spores and small size. Often in mature plants the sterile base appears somewhat cellular, but this condition is usually not apparent in mature plants.

I consider *Bovista olivacea* Cke. et Mass. but a synonym, for the original description is well covered by that given above. Lloyd (1905, p. 37) has examined the type specimen at Kew and states it is similar to *C. candida* but differs in the larger, thicker peridium, and more deeply coloured capillitium. Examination of individual plants in any abundant collection of *C. candida* will show that these differences are insufficient as specific characters, for the Australian forms range in size from 2 cm. to 7 cm. in diameter; the peridium is in young plants 1-2 mm. thick, and the colour of the capillitium varies according to whether the plants were collected while fresh or when weathered.

Var. RUBRO-FLAVA (Cragin), n. comb.

Calvatia rubro-flava (Cragin) Lloyd, *Myc. Notes*, 1902, 90.—*Lycoperdon rubro-flavum* Cragin, *Bull. Washburn Coll.*, 1, 1885, 30.—*Calvatia aurea* Lloyd, *Myc. Notes*, 1899, 11.

Closely resembling the preceding but separated by the reddish-ochre colour of the gleba.

Distribution.—North America; Australia.

New South Wales: *Neutral Bay, Mar., 1916.

I have compared Dr. Cleland's specimens with specimens kindly donated by Dr. Coker, University of North Carolina (No. 7163) and find them to be identical in all particulars save that of size, the Australian specimens being somewhat larger.

Var. FUSCA, n. var.

Closely resembling *C. candida* but differing in that the gleba is dark olivaceous, almost fuscous.

Distribution.—Australia.

South Australia: *Kinchina, July, 1923.

I believe it inadvisable to erect species upon the colour of the gleba alone, so have considered *C. rubro-flava* as being a variety of *C. candida*, for it agrees in all other particulars. The variety *fusca* is based on a single specimen which differs from *C. candida* only in the darker colour of the gleba.

If one were to consider glebal colour alone as being of specific value then many species must be erected in related genera; for example in *Disciseda hyalothrix* may occur specimens with olivaceous or purple gleba, yet these forms are not considered as being distinct species. Further, some plants of *C. rubro-flava* closely approach in colour certain plants of *C. candida*; and bleached specimens also appear so similar that separation becomes difficult and frequently impossible.

This is a matter of opinion, however, and to those desirous of basing species on glebal colour these two varieties would be considered as distinct species.

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EXPLANATION OF PLATES XXIII-XXIV.

Plate xxiii.

1. *Calvatia lilacina*. Natural size. Sterile base only; note the conspicuous diaphragm.

2. *Calvatia gigantea*. × ¼. Showing the rooting base and smooth, leathery exoperidium.

Plate xxiv.

3. *Calvatia caelata*. × 0·9. The areolate, floccose exoperidium is here well shown.

4. *Calvatia candida*. × 0·9. The plant on the right is inverted to show the rooting base. Note the furfuraceous exoperidium, strongly fissured in these plants.

5. *Calvatia candida*. × 1·8. Section showing the sterile base. In this photograph the base appears distinctly cellular owing to the fact that the plant is not yet mature.

All photographs by H. Drake.

NEW SPECIES OF AUSTRALIAN PROCTOTRYPOIDEA, WITH REVISIONAL NOTES.

By Alan P. Dodd.

[Read 30th June, 1926.]

This small paper describes one new genus in the family Scelionidae, and ten new species in the families Scelionidae, Belytidae, and Diapriidae. At the same time, the genera *Dichoteleas* Kieffer and *Neoscelio* Dodd in the Scelionidae are redescribed, and notes given on the Diapriid genera *Neopria* Dodd and *Propentapria* Dodd.

Family Scelionidae.

Dichoteleas Kieffer.

(*Berlin. Ent. Zeitschr.*, 51, 1907, 297.)

Head transverse, the vertex thin; eyes very large, bare; ocelli large, the lateral pair close to the eyes; viewed from in front the head is as wide as deep; frontal depression large and shallow, feebly margined above; cheeks narrow; mandibles large, curved, bidentate, the teeth acute. Antennae 12-jointed; in the female the funicle joints are elongate, the club slender and 7-jointed; in the male the flagellar joints are filiform. Thorax stout, no longer than its greatest width; from lateral aspect, as long as high; pronotum very short; scutum large, much wider than long, broadly rounded anteriorly; parapsidal furrows narrow and obscured by the sculpture, but complete; scutellum transverse, on either side just out from base with a large stout tooth or spine; postscutellum projecting narrowly as a very transverse plate, at meson with a large acute tooth or short spine; propodeum very short and excavated at the meson in both sexes, laterally with a patch of white pubescence; tegulae large; propleurae depressed; mesopleurae with a long oblique dorsoventral depression. Forewings long and broad, when closed reaching apex of abdomen; submarginal vein attaining the costa at distinctly beyond one-half the wing length; marginal vein punctiform, the stigmal vein long, the postmarginal fully twice as long as the stigmal; radial vein indicated, the basal and median veins not showing. Legs normal; coxae of moderate size; tibiae and tarsi hairy, but not spinous. Abdomen somewhat longer than the head and thorax united, two and one-half times as long as its greatest width; ovate, narrowed at base, blunt posteriorly; viewed from the side almost flat dorsally and ventrally; segment 1 about as long as its greatest width, faintly elevated at base; 2 and 3 about subequal in length, somewhat longer than 1 or 4; 5 much shorter than 4; 6 quite short.

Type, *D. rugosus*.

Kieffer erected this genus for a male from Mackay, Queensland. In my collection there is what is evidently the opposite sex of the genotype, and also both sexes of a second species. Kieffer has made the statement that the parapsidal furrows are absent. Some years ago, I had the opportunity of examining the

unique example of the genotype in the British Museum, finding that, as in the material of my own collecting, these furrows are complete but delicate and more or less obscured by the sculpture.

Dichoteleas would not seem to have been recorded from outside Australia; its nearest allies would appear to be the Australian *Neoscelio* Dodd and the Oriental *Merriwa* Dodd. In *Neoscelio*, the postmarginal vein is wanting, while in *Merriwa* the postscutellum is armed with two teeth. Some of the points of resemblance and difference between *Neoscelio* and *Dichoteleas* are pointed out when discussing the former genus. It is well to note that the legs in *Dichoteleas* are much less spiny, and that the antennal club, although slender, is truly 7-jointed.

Table to the Species of Dichoteleas.

Thorax wholly black, the scutellar spines concolorous; first five antennal joints in the female dark-brownish; first funicle joint in the female less than twice as long as the second; median lobe of scutum longitudinally striate; abdominal segments 2-4 without a median carina .... *rugosus* Kieffer

Thorax more or less metallic-blue; the scutellar spines yellow; first four antennal joints in the female bright yellow; first funicle joint in the female more than twice as long as the second; median lobe of scutum without noticeable striae; abdominal segments 2-4 with a distinct median carina .... *subcoeruleus*, n. sp.

Dichoteleas rugosus Kieffer.

(*Berlin. Ent. Zeitschr.*, 51, 1907, 297.)

♀. Length, 4 mm. Black; legs, including the coxae, bright lemon-yellow, the posterior tarsi and apex of posterior tibiae dusky; first five antennal joints more or less brownish, the rest black; mandibles reddish, the teeth black; tegulae yellow.

Upper frons moderately coarsely rugose-punctate or reticulate-punctate, and with several irregular longitudinal striae; around ocelli irregularly rugose-punctate; upper face and vertex with semi-recumbent black pubescence; frontal depression smooth mesially, laterally with striae which converge toward the mouth; cheeks with numerous small setigerous punctures. Antennal scape as long as the next three joints combined; pedicel almost twice as long as its greatest width; funicle 1 very long, rather more than twice as long as the pedicel; 2 a little more than one-half as long as 1; 3 a little longer than wide; club not much wider than the funicle, 7-jointed, the joints a little wider than long. Scutum with dense pale pubescence; with numerous small punctures, the punctures denser and confluent on the lateral lobes, the median lobe with numerous fine longitudinal striae which are more distinct posteriorly; parapsidal furrows obscure and delicate, but complete; scutellum densely pubescent and with numerous small punctures; depression of mesopleurae smooth, above this with several strong longitudinal striae; metapleurae finely rugose-punctate and pubescent. Forewings lightly smoky, the venation thick and fuscous. Segment 1 of abdomen strongly striate; 2 and 3 densely and rather finely rugose-punctate and with numerous wavy and irregular longitudinal striae or rugae; 4 and 5 with similar finer sculpture but smooth mesially except for pin-punctures; 6 finely rugose; 4-6 with dense pubescence, which is very short and not conspicuous on 2 and 3.

♂. Antennal scape and pedicel yellow; the first flagellar joint suffused with yellow, the remainder black; pedicel no longer than wide; funicle 1 longest, at least four times as long as wide; 2-9 gradually shortening; 3 very feebly excised.

Habitat.—North Queensland: Mackay (type); Cairns district, one female in January, A. P. Dodd.

Type in the British Museum.

Several years ago I made a few notes on the type specimen in the British Museum, from which it was possible to associate the female described above with Kieffer's species, and there seems little doubt but that this identification is correct.

DICHOTELEAS SUBCOERULEUS, n. sp.

♀. Length, 4·25-4·5 mm. Black; head, scutum, and scutellum deep metallic-blue; tegulae and the scutellar spines pale yellow, the postscutellar spine black; legs, including the coxae, bright golden-yellow, the posterior tarsi and apex of posterior tibiae dusky; first four antennal joints bright yellow, the remainder black.

Eyes very large, converging somewhat above; around the ocelli and the frons with large, dense, rather shallow punctures, laterally on either side of frons with two strong longitudinal striae, one of which is against the eye margins; frontal depression smooth; mouth with strong converging striae; frons with scattered pubescence; occiput smooth, except for a few pin-punctures. Antennal scape as long as the next three joints united; pedicel one-half longer than its greatest width; funicle 1 very long, fully three times as long as the pedicel; 2 somewhat less than one-half as long as 1; 3 a little widened and not much longer than wide; club slender, 7-jointed, the joints a little wider than long. Pronotum transverse, with fine, dense, setigerous punctures; parapsidal furrows rather wide apart and almost parallel, delicate but complete; median lobe with a complete obtuse median carina; lateral lobes with an obtuse median carina that disappears anteriorly, and against the tegulae there is a narrow groove with carinated margins; surface of scutum with shallow indefinite punctures bearing fine white setae; scutellum smooth, except for a few shallow punctures bearing setae. Forewings lightly smoky, the venation thick and fuscous. Segment 1 of abdomen strongly striate; 2-4 with a strong median carina which disappears posteriorly on 4; 2 and 3 confluently rugose-punctate, and with several wavy irregular longitudinal striae or rugae; 4 and 5, and lateral margins of 2 and 3 very finely, densely punctate; segments, except 1, with fine, dense, short pubescence.

♂. Metallic tint hardly noticeable on head and thorax. Antennae black, the first two joints yellow, the third brownish; pedicel scarcely longer than wide; funicle 1 lengthened, one-half longer than 2, which is fully twice as long as wide; 2-9 gradually shortening; 3 feebly excised on one side.

Habitat.—North Queensland: Mossman, two females in April; Cairns district, 1,100 feet, one male, one female, in January.

Type in South Australian Museum; cotypes in the author's collection.

NEOSCELIO Dodd.

(*Trans. Royal Soc. S. Aust.*, xxxvii, 1913, 138.)

Head, viewed from above, transverse, the vertex thin; eyes large, with a few scattered setae; ocelli large, the lateral pair closer to the median ocellus than to the eye margins; vertex sloping to the occiput which is feebly margined and from the dorsal aspect gently concave; from lateral aspect the head is almost straight from the median ocellus to the mouth; viewed from in front the head is wider than deep; antennal depression large, circular, and shallow, immargined; cheeks not broad; antennal prominence very conspicuous; mandibles long, bi- or tridentate, the outer teeth long, the inner tooth, where tridentate, small. Antennae 12-jointed in both sexes; in the female, the first funicle joint is much longer than the preceding or following joint, the club 6-jointed; in the male the pedicel is short, the flagellar joints filiform. Thorax stout; viewed from above, not much longer

than its greatest width; viewed from the side, as high as long; pronotum visible laterally, its anterior angles rounded or subacute; scutum much wider than long, the parapsidal furrows not evident; scutellum semicircular, at one-half its length laterally with a stout or acute tooth; postscutellum short, armed at the meson with a long slender spine, which is as long as the scutellum and projects high above the basal abdominal segment; propodeum rather abruptly declivous, short at meson, longer laterally, and with a straight carina on either side at one-half its width from the median line; propleurae, for the most part, excavated; mesopleurae with a deep dorsoventral impression. Coxae large, the legs slender; tibiae and tarsi spinous; tibiae, at apex, with one long spine and several shorter ones. Forewings long and broad; when closed extending somewhat beyond apex of abdomen; venation thick and distinct, the submarginal vein terminating at about one-half the wing length in a thickened quadrate marginal vein; stigmal vein moderately long, the postmarginal absent; a more or less distinct stigmal spot is present; basal, median, and radial veins indicated. Abdomen shaped much as in the genera of the Teleasinae (*Hoplogryon* Ashmead, *Trimorus* Foerster, etc.); pyriform, narrowed at base, rounded posteriorly; not more than twice as long as its greatest width; no longer than the head and thorax united; viewed from the side, straight or gently convex above, the first segment straight beneath, the remainder convex, especially in the female; segments all wider than long, 3 somewhat longer than 2, and almost as long as the following segments united.

Type, *Neoscelio gloriosus* Dodd.

In the original description of this genus, the writer overlooked the presence of the teeth on the scutellum, and from the characters of the venation wrongly inferred a relationship with *Scelio* Latreille. Its nearest ally would, however, appear to be another Australian genus, *Dichoteleas* Kieffer; both possess the lateral teeth on the scutellum, and a spine or tooth on the postscutellum; but *Dichoteleas* has a long postmarginal vein, the abdomen is longer, its segments more uniform in length, and when viewed from the side is almost flat above and beneath. In all five species of *Neoscelio*, the postscutellar spine is very long, whereas in the two species of *Dichoteleas* the spine is comparatively short.

Neoscelio was founded on a single species from Mt. Tambourine, South Queensland; to this must be added three further species from the same locality, and one from the Cairns district, North Queensland. All five bear close structural and sculptural resemblances, are of about the one size, and bear a marked superficial likeness to members of the Teleasinae genera *Hoplogryon* and *Trimorus*, but the latter are of considerably smaller size.

Table to the Species of Neoscelio.

1. Trochanters contrasting black; forewings not uniformly smoky, with one or two hyaline bands .... *pulchralis*, n. sp.
   Trochanters concolorous with the legs; forewings uniformly smoky, without bands.. 2
2. Thorax not wholly black, at least the propodeum and the sides red 3
   Thorax wholly black 4
3. Size larger, 5·5 mm.; scutum mostly red, the pronotum red; abdomen longer .... *rubidus*, n. sp.
   Size smaller, 3·5 mm.; scutum black, also the pronotum; abdomen shorter .... *lateralis*, n. sp.
4. Segment 3 of abdomen much longer than 2; lateral ocelli separated from the eyes by more than their own diameter .... *gloriosus* Dodd.
   Segment 3 of abdomen not much longer than 2; lateral ocelli separated from the eyes by one-half their own diameter .... *agilis*, n. sp.

NEOSCELIO GLORIOSUS Dodd.

(*Trans. Royal Soc. S. Aust.*, xxxvii, 1913, 138.)

♀. Length, 5 mm. Black; legs, including the coxae, bright reddish-yellow; first six antennal joints reddish-yellow, the club black; mandibles red.

Vertex of head coarsely rugose; frons strongly longitudinally rugose-striate, except for the large smooth depression; lateral ocelli separated from the eyes by more than their own diameter; mandibles bidentate, the teeth long, the outer tooth much the longer. Antennal scape moderately long and slender; pedicel one-half longer than its greatest width; funicle 1 two-thirds longer than the pedicel and more than one-half as long as the scape, nearly four times as long as its greatest width; 2 hardly one-half as long as 1; 3 and 4 somewhat wider than long; club joints all somewhat wider than long. Thorax with a few, scattered, long fine setae; scutum with very large confluent punctures with an irregular longitudinal arrangement; scutellum with large confluent punctures with a reticulate arrangement; teeth on scutellum stout and blunt. Forewings stained rather deeply brownish; venation fuscous, thick and distinct. Abdomen fully twice as long as its greatest width; segment 1 as long as the width at one-half its length; 2 scarcely longer than 1; 3 very distinctly longer than 2, not as long as 1 and 2 combined, but almost as long as 4-6 combined, somewhat less than twice as wide as long; 4 one-half as long as 3; 6 quite short; 1 with nine strong irregular longitudinal striae, the surface between the striae opaque; median stria of segment 1 continued on segment 2 as a strong median carina, which is replaced on segment 3 by a narrow smooth median line; segments 2-5 with large subconfluent punctures with a tendency toward longitudinal arrangement; ten of these punctures are present in a longitudinal count at meson of 3; posterior margin of 3 and 4 very narrowly smooth; punctures setigerous.

♂. Unknown.

Habitat.—South Queensland: Mt. Tambourine, 2,000 feet; one female taken by Mr. A. M. Lea. The type remains unique.

Type in South Australian Museum, I. 1371.

NEOSCELIO RUBIDUS, n. sp.

♂. Length, 5·5 mm. Head black; thorax rich red, the scutellum, spine on postscutellum, and a patch on the posterior half of the scutum at the meson, black; abdomen wholly black; first six or seven antennal joints clear reddish-yellow, the apical five or six joints black; legs wholly clear reddish-yellow; mandibles red, their teeth black.

Head with a scattered pubescence of long fine silky hairs; frons strongly longitudinally rugose-striate, between the striae densely, moderately finely punctate, the punctures subobsolete on either side of the long, smooth antennal impression; vertex behind the ocelli strongly confluently reticulate- or rugose-punctate, laterally with an oblique tendency; cheeks with several longitudinal striae, between which are shallow punctures; mandibles tridentate, the middle tooth small; lateral ocelli separated from the eyes by fully their own diameter. Antennae normal; scape rather stout; pedicel small, hardly longer than wide; funicle 1 more than twice as long as the pedicel, and about one-half as long as the scape; 2 two-thirds as long as 1; 3-9 moniliform, each a little longer than wide; 3 feebly excised on one margin. Pronotum densely rugose-punctate and pubescent; scutum and scutellum densely, strongly, reticulate- or rugose-punctate, and with sparse long fine pubescence; lateral teeth of the scutellum short and acute; spine

on postscutellum very long and slender, almost as long as the scutellum, with two strong median carinae for one-half its length; propodeum rugose-punctate, laterally with dense white pubescence; depression of mesopleurae smooth and polished, with one row of punctures toward the posterior margin; anterior of the depression the surface is densely finely punctate and pubescent; metapleurae densely punctate and pubescent. Forewings smoky, without bands; venation fuscous, thick and distinct. Abdomen two and one-half times as long as its greatest width; segment 1 rather longer than its greatest width; 2 and 3 subequal in length; 3 twice as wide as long; 4 two-thirds as long as 3; 1 rugose-punctate, the raised mesial area with several strong longitudinal striae; 2 foveate at base; 2-6 very densely, subconfluently punctate, the punctures moderately large, the longitudinal tendency hardly indicated; there are about 12 punctures in a longitudinal count on segment 3; sides of abdomen, segments 5 and 6 and apical third of 4, with a conspicuous pubescence of long yellow hairs; rest of abdomen dorsally with scattered inconspicuous pubescence.

♀. Unknown.

Habitat.—South Queensland: Mt. Tambourine, 2,000 feet; three males taken by the author in December.

Type in South Australian Museum; cotypes in the author's collection.

NEOSCELIO AGILIS, n. sp.

♀. Length, 4-4·5 mm. Black; legs, including the coxae, bright reddish-yellow, the tarsi dusky; antennal scape reddish-yellow, the next four joints sometimes washed with yellow, sometimes wholly fuscous, the club black; mandibles reddish-yellow, also the tegulae.

Ocelli close together, the lateral pair separated from the median ocellus narrowly and from the eye margins by about one-half their own diameter; vertex and frons, except the smooth shallow depression, rather strongly longitudinally striate; between the striae are obscure shallow punctures, each bearing a long fine seta; striae disappearing toward the occiput; cheeks with obscure shallow punctures and one median carina; mandibles tridentate, the outer teeth long and acute, the middle tooth very small. Antennal scape long and slender; pedicel less than twice as long as its greatest width, as long as funicle 2; funicle 1 long and slender, fully one-half as long as the scape, and two and one-half times as long as the pedicel; 3 quadrate; 4 wider than long. Scutum with large confluent elliptical punctures arranged in irregular longitudinal lines, there being ten punctures in the median line; scutellum with large confluent punctures arranged reticulately; punctures of pronotum, scutum, and scutellum each bearing a long fine black seta; scutellar teeth stout and acute; propodeum laterally with a patch of white pubescence. Forewings stained light brownish; venation fuscous, thick, and distinct. Abdomen twice, or less, as long as its greatest width; segment 3 only slightly longer than 2; surface shining; segments 2-5 with very large punctures, confluent, and arranged in irregular longitudinal lines on 2 and 3 (only five punctures are present in each row); punctures dense but not confluent on 4 and 5; posterior margin of 2-4, and base of 4 and 5 with a narrow transverse path which is minutely punctate; median carina on segment 2 not differentiated.

♂. Resembling the female but the abdomen, from lateral aspect, is almost flat above and beneath, and the punctures on the abdomen are somewhat smaller. Antennal scape yellow, the flagellum fuscous, the basal three or four joints sometimes suffused with yellow; scape rather short; pedicel scarcely longer than wide;

funicle 1 more than twice as long as the pedicel; 2 plainly, but not greatly, shorter than 1; 3 very feebly excised on one side; 4-9 subequal, rather less than twice as long as wide.

Habitat.—North Queensland: Cairns district, 0-1,500 feet; a long series taken by the author in January-May, September-December.

Type in South Australian Museum; cotypes in the South Australian Museum, Queensland Museum, and the author's collection.

This species agrees exactly in colour with the genotype, but there are structural and sculptural differences. For instance, in *gloriosus*, segment 3 of the abdomen is very distinctly longer than 2, the lateral ocelli are separated from the eye margins by more than their own diameter, and the first funicle joint of the antennae is not so long in relation to the pedicel.

NEOSCELIO LATERALIS, n. sp.

♀. Length, 3·5 mm. Head, prothorax, scutum, scutellum, postscutellum, and the abdomen, black; rest of thorax bright red; legs, including the coxae, bright reddish-yellow; antennal scape reddish-yellow, the next four or five joints somewhat dusky, the club black; mandibles red.

Lateral ocelli separated from the median ocellus by nearly their own diameter, and from the eye margins by somewhat more than their own diameter; frons longitudinally striate, between the striae with moderately small and dense punctures, each bearing a long fine seta; behind the ocelli the surface is densely punctate, the punctures of moderate size and setigerous; mandibles tridentate, the middle tooth very small. Antennal scape moderately long; pedicel one-half longer than its greatest width; funicle 1 barely twice as long as the pedicel; 2 shorter than the pedicel and not much longer than wide; 3 and 4 somewhat wider than long. Scutum and scutellum with large confluent punctures, with a tendency, which is more pronounced posteriorly, to longitudinal arrangement, there being about twelve punctures in a longitudinal count at the median line of the scutum; arranged reticulately on the scutellum; teeth on scutellum short, stout, and subacute. Forewings rather deeply smoky throughout; venation fuscous, thick and distinct, the stigmal vein rather short. Abdomen rather distinctly less than twice as long as its greatest width; segment 3 fully twice as wide as long, not much longer than 2, and less than twice as long as 4; 2 and 3 densely punctate, the punctures with a tendency toward longitudinal arrangement, there being seven or eight punctures in a longitudinal count on 3; posterior margin of 2-4, and anterior margin of 4 and 5, with a narrow path which is finely pin-punctate; base of 1 with a small faint smooth elevation; punctures of 2 and 3 not setigerous; 4 and 5 with dense nonconfluent punctures which bear long fine setae.

♂. Agreeing with the female. Antennae fuscous, the scape and pedicel yellow; as in *agilis*.

Habitat.—South Queensland: Mt. Tambourine, 2,000 feet; a small series taken by the author in February; Blackall Range, one female, three males in January.

Type in South Australian Museum; cotypes in the South Australian and Queensland Museums, and the author's collection.

This species is somewhat smaller than *agilis*, and the punctures of the thorax and abdomen are not as large as in that species; there are few punctures behind the ocelli in *agilis*; the first funicle joint of the antennae is longer in that species; and the lateral ocelli, although nearer to the median ocellus, are separated from the eye margins by less than their own diameter. Moreover, the smooth frontal

depression is smaller in *lateralis* and rather broadly separated from the eyes, and the punctures between the striae on the frons are more pronounced.

NEOSCELIO PULCHRALIS, n. sp.

♀. Length, 3·5 mm. Head and abdomen black; thorax rich red, the scutum, scutellum and postscutellum, black; legs, including the coxae, bright reddish-yellow, the trochanters black, the anterior femora sometimes somewhat dusky; first six antennal joints reddish-yellow, the scape sometimes more or less dusky, the club black; mandibles red.

Frons confluently punctate, the punctures not large, and with scattered silvery pubescence; behind the ocelli and the cheeks rugose-punctate and with dense silvery pubescence; frontal depression smooth, moderately large; mandibles tridentate, the middle tooth small; lateral ocelli separated from the median ocellus by rather less than their own diameter, and from the eyes by somewhat more than their own diameter. Antennal scape moderately long; pedicel fully one-half longer than its greatest width; funicle 1 one-third longer than the pedicel, twice as long as 2, which is quadrate; 3 and 4 wider than long. Scutum and scutellum with large confluent punctures, with a tendency toward longitudinal arrangement on the scutum, reticulate on the scutellum; teeth on scutellum short and acute. Forewings dusky, the basal two-fifths, up to the marginal vein, subhyaline; more rarely there is a hyaline cross-band some distance from the apex; venation fuscous, thick and distinct, the stigmal vein rather short. Abdomen somewhat less than twice as long as its greatest width; segment 3 fully twice as wide as long, and slightly longer than 2; 4 fully one-half as long as 3; 1 strongly striate, faintly elevated and smooth at base; 2 and 3 with large confluent punctures arranged in irregular longitudinal lines, there being eight or nine punctures in a longitudinal count on 3; 4 and 5 densely but not confluently punctate; posterior margin of 2, 3, and 4, and anterior margin of 4 and 5, narrowly pin-punctate.

♂. Second band of wing always absent. Antennae variable in colour, the first five joints sometimes bright yellow, sometimes almost wholly dusky. Pronotum, sides of the thorax, and the coxae sometimes more or less dusky.

Antennal scape stout; pedicel hardly longer than its greatest width; funicle 1 almost twice as long as the pedicel, hardly twice as long as its greatest width; 2 slightly longer than wide; 3-9 scarcely longer than wide.

Habitat.—South Queensland: Mt. Tambourine, 2,000 feet; five females, ten males taken in December by the author.

Type in South Australian Museum; cotypes in the South Australian Museum, Queensland Museum, and the author's collection.

The first flagellar joint in both sexes is shorter than in *lateralis*; for example, in the male antennae of *lateralis*, this joint is more than twice as long as the pedicel and in the female is about twice as long as the pedicel (one-third longer than the pedicel in *pulchralis*).

The variation in the fasciation of the forewings is interesting; the second band is present in only one female, but occurs in the three examples of the variety described beneath.

NEOSCELIO PULCHRALIS Dodd, var. MEDIALIS, n. var.

♀. Scutum and scutellum rich red, each with a black patch medially. Forewings with two cross-bands.

Habitat.—South Queensland: Mt. Tambourine, 2,000 feet; two females in December, one female in February, A. P. Dodd.

Type in South Australian Museum; cotypes in the author's collection.

DUARINA, n. gen.

♀. Small and stout. Head large, somewhat wider than the thorax; viewed from above, twice as wide as long, the vertex rather long, the longitudinal distance from the anterior ocellus to the occipital margin being considerably greater than the transverse distance between the eyes at the ocelli; occipital line concave and margined; viewed from in front, the head is wider than deep; frontal depression shallow and not margined; cheeks moderately narrow; eyes large, bare, but well separated from the occipital line; ocelli small, wide apart, the lateral pair against the eyes; mandibles tridentate. Antennae 12-jointed; scape slender; funicle joints short, the club stout, compact, 6-jointed. Thorax not much longer than its greatest width; viewed from the side, fully as high as long; pronotum hardly visible from above; scutum large, the parapsidal furrows wide apart, delicate, complete, and almost parallel; scutellum of moderate length, projecting somewhat over the propodeum, its posterior margin rather deeply concave, postscutellum unarmed; propodeum almost perpendicular, short, from dorsal aspect somewhat hidden by the scutellum. Forewings when closed not extending beyond apex of abdomen; short and moderately broad; banded; submarginal vein attaining the costa at somewhat beyond one-half the wing length, the marginal vein linear, distinctly longer than the stigmal vein which is short and oblique, the postmarginal vein not developed. Legs normal, slender; posterior tarsi hardly as long as their tibiae, their basal joint as long as 2-5 combined. Abdomen broadly oval, somewhat narrowed at base, one-half longer than its greatest width, and rather wider than the thorax; segment 1 very short, transverse; 2 twice as long as 1; 3 somewhat longer than 1 and 2 or 4-6 combined, occupying a little less than one-half of the abdomen; 4, 5, and 6 short and transverse.

This genus comes near to *Anteris* Foerster, which is well represented in Australia; it differs mainly in the deeply concave posterior margin of the scutellum. The affinity with *Anteris* is indeed close; both possess the same shaped head, the stout abdomen with the long third segment, the short antennae; in both the postmarginal vein is not developed. However, in *Anteris* the postscutellum bears an acute tooth, and the marginal vein is shorter in relation to the stigmal vein. In none of the species of *Anteris* known to me are found definitely banded wings.

Type, *Duarina venustella*, n. sp.

DUARINA VENUSTELLA, n. sp.

♀. Length, 1·5 mm. Head, thorax, and first two abdominal segments black; rest of abdomen intense orange; antennae black, the club brown at base and becoming pale yellow on the apical joints; coxae fuscous, the legs dusky-brown, the trochanters and tarsi yellow.

Head with very fine, impressed, polygonal reticulation and with scattered very small punctures each bearing a short fine seta; frontal depression smooth. Antennal scape slender; pedicel one-half longer than its greatest width; funicle 1 much smaller, no longer than wide, 2-4 wider than long; club 6-jointed, the joints transverse. Scutum with similar sculpture to the head; scutellum finely and very densely rugose-punctate. Forewings stained yellowish, and with two dark transverse bands, the first involving apical fourth of the submarginal and all of the marginal veins, the second at the wing apex; venation fuscous, the stigmal vein pale yellow. Abdominal segments 1 and 2 strongly longitudinally striate; 3 finely striate at base and laterally, smooth for the rest; 4-6 with fine polygonal sculpture and a few setigerous pin-punctures.

♂. Unknown.

Habitat.—South Queensland: Mt. Tambourine, two females in February, A.P.D. Type in South Australian Museum; cotype in the author's collection.

A striking little species. The contrast between the sculpture of the scutum and scutellum is rather curious.

Family Belytidae

ISMARUS Haliday.

This genus is characterized by the absence of parapsidal furrows, and the shape of the head, which is much more transverse than is usual for the family; the antennal prominence very small and inconspicuous. Not many species have been described, chiefly from Europe, and one from North America. The following species differs from the generic diagnosis, as given by Kieffer, in the raised, margined posterior border of the scutellum, and the thickened posterior tibiae.

ISMARUS TIBIALIS, n. sp.

♀. Length, 2·30 mm. Black, shining; legs, including the coxae, bright golden-yellow, the posterior tibiae and tarsi dusky-brown, the basal joint of the posterior tarsi black; tegulae yellowish; basal three or four antennal joints yellow, the remainder more or less suffused with yellow, the apical ones fuscous.

Head, viewed from above, transverse, somewhat distinctly wider than the thorax, the vertex short; viewed from in front, distinctly wider than deep; eyes moderately large, bare; ocelli of moderate size, the lateral pair much closer to the median ocellus than to the eyes; antennal prominence small, not visible from above; surface smooth and shining, with a few scattered fine setae. Antennae 15-jointed, without a club, the apical joints not thickened; scape short and stout, not much longer than funicle 1; pedicel two-thirds longer than its greatest width; funicle 1 more slender than the pedicel and distinctly longer; 2 as long as 1; 3 plainly shorter than 2; 4-12 moniliform, each about one-third longer than wide, the apical joint one-half longer. Thorax rather stout; pronotum very short at meson, more distinct laterally, densely punctate and pubescent; scutum from lateral aspect convex, from dorsal aspect subquadrate, the anterior margin feebly convex, smooth and shining, without parapsidal furrows; in front, on either side near the anterior margin there is a large circular fovea; there is a deep groove containing setigerous punctures against the tegulae, and there is a curved row of six white setae on either side on the posterior third, wide apart anteriorly, approximating at the posterior margin, together forming a broadly open U of setae whose base rests against the posterior margin of the scutum; scutellum trapezoidal, almost twice as wide anteriorly as posteriorly, the lateral and posterior margins straight and finely carinate, the posterior angles prominent in the form of tubercles; at base with two large deep foveae, narrowly separated, each fovea divided by several longitudinal carinae; against the lateral margins are several small setigerous punctures; from lateral aspect the scutellum is raised, perpendicularly truncate posteriorly; propodeum quite short, its posterior border margined, its posterior angles prominent, at meson with a raised tubercle; propleurae densely punctate except for a smooth depressed area; mesopleurae smooth and shining; metapleurae rugose and with long white pubescence. Forewings broad, when closed extending somewhat beyond apex of abdomen; faintly tinted; submarginal vein attaining the costa a little before one-half the wing length, the marginal vein long, the stigmal vein short; radial cell closed, small, one-half as long as the marginal vein; radial vein directed backward shortly. Hindwings with

one closed cell. Legs normal, except that the posterior tibiae are much thickened. Abdominal petiole short, twice as wide as long, strongly striate; body of abdomen, from lateral aspect, convex; composed of six segments; segment 2 (first body segment) occupying three-fifths of the surface; 3-5 transverse; 6 a little longer; 7 (apical segment) also short; abdomen smooth and shining, segments 3-7 with a few scattered setae.

♂. Unknown.

Habitat.—North Queensland: Cairns district, four females taken by Mr. F. P. Dodd on flowers in March.

Type in South Australian Museum; cotypes in the author's collection.

Family Diapriidae.

NEOPRIA Dodd.

(*Trans. Royal Soc. S. Aust.*, xxxix, 1915, 429.)

This genus approaches *Idiotypa* Foerster, from which it differs, apparently, in the antennal club being abruptly 3-jointed, and in the presence of three foveae at the base of the scutellum. However, certain American species described under *Idiotypa*, notably *I. pallida* Ashmead and *I. pallipes* Fouts, possess the three foveae. Perhaps *Neopria* cannot be considered a distinct genus.

The species described below differs from the other Australian forms in the wings being vestigial.

NEOPRIA VESTIGIALIS, n. sp.

♀. Length, 1·25 mm. Head, thorax, and petiole of abdomen, very dark red-brown; body of abdomen bright orange-yellow; legs bright yellow; antennae deep yellow, the three club joints fuscous.

Head, from dorsal aspect, subquadrate, not much wider than long; smooth and shining; eyes small, with a few short hairs; ocelli either very minute or absent. Antennae 12-jointed; scape normal; pedicel stout, no longer than its greatest width; funicle joints small, 1 much narrower than the pedicel, somewhat wider than long, 2-7 transverse, 7 a little widened; club very abrupt, 3-jointed, joints 1 and 2 somewhat wider than long. Thorax slender, somewhat narrower than the head, twice as long as its greatest width, smooth and shining; parapsidal furrows deep and complete; scutellum with three rather small circular foveae at base; median carina of the propodeum elevated posteriorly. Wings vestigial, bristle-like, reaching as far as the posterior margin of the abdominal petiole. Petiole of abdomen fully as wide as long, finely densely longitudinally striate; body of abdomen plainly wider than the thorax, fully twice as long as its greatest width, its base shortly striate and with a short median groove; smooth and shining; segment 2 occupying four-fifths of the surface, the remaining segments short and transverse.

♂. Unknown.

Habitat.—South Queensland: Mt. Tambourine, 2,000 feet; one female in February, A. P. Dodd.

Type in South Australian Museum.

PROPENTAPRIA Dodd.

(*Trans. Royal Soc. S. Aust.*, xxxix, 1915, 425.)

This genus differs from *Paramesius* Westwood only in the form of the basal foveae of the scutellum; in *Paramesius* two large foveae may be present, or one only; *Propentapria* has the basal fovea subdivided by longitudinal carinae, so that

five foveae are present, of which the outer two are circular, the inner three narrow. Possibly the distinction is not great enough to allow full generic rank to *Propentapria*, but as three species have been discovered in which this character remains constant, no alteration is considered necessary at present.

Table of Species of Propentapria.

1. Body black, the antennae wholly black .... *multifoveata* Dodd.
   Head and abdomen black, the thorax chestnut-red; at least the first six antennal joints bright red 2
2. Marginal vein longer, about one-fourth as long as the submarginal; foveate area at base of scutellum oval, twice as wide as long; second funicle joint of male antennae as long as the scape and nearly four times as long as the first ...... *venusta*, n. sp.
   Marginal vein shorter, no more than one-sixth as long as the submarginal; foveate area at base of scutellum with its posterior margin concave, four times as wide as long; second funicle joint of male antennae less than one-half as long as the scape, and not twice as long as the first .... *consimilis*, n. sp.

PROPENTAPRIA VENUSTA, n. sp.

♀. Length, 3-3·5 mm. Head and body of abdomen black; thorax and petiole of abdomen bright chestnut-red, the scutum, except the posterior half of the median lobe, and most of the mesopleurae, dusky-black; legs wholly reddish-yellow; first six antennal joints bright red, the next two dusky, the apical five black.

Body normal; smooth and shining; head and thorax with a few small scattered punctures giving off long fine setae. Head normal, subglobular; from dorsal aspect less than twice as wide as long; eyes moderately small; ocelli normal; antennal prominence rather conspicuous; face below antennal prominence with fine, more numerous setae. Antennae two-thirds as long as the body; 13-jointed; scape very long and slender, fully as long as the next four joints combined; pedicel one-half longer than its greatest width; funicle 1 somewhat narrower and longer than the pedicel, almost three times as long as its greatest width; 2-6 gradually shortening; 6 somewhat longer than wide; club ill-defined, 5- or 6-jointed, the joints, except the last, quadrate, the apical joint fully twice as long as the penultimate. Thorax twice as long as its greatest width; pronotum not long, but plainly visible, especially on the sides; scutum narrowed anteriorly, almost as long as its greatest width, the parapsidal furrows well-marked and complete, the median lobe convex, the lateral lobes feebly depressed and with a punctate groove running round the outer margin; depression at base of scutellum oval, hardly twice as wide as long, subdivided into five narrow foveae of which the outer two are largest; lateral margins of the scutellum with a shallow obscure fovea; propodeum long, at base with a small raised blunt tooth or tubercle, its surface with several irregular longitudinal carinae or rugae; propleurae depressed, against the posterior margin with a row of small foveae or punctures; mesopleurae large, quadrate, smooth, with two longitudinal grooves against the dorsal and ventral margins; metapleurae rather coarsely rugose-punctate. Forewings when closed reaching apex of abdomen; broad; lightly clouded; venation terminating at slightly beyond one-half the wing length; marginal vein very long, about one-fourth as long as the submarginal, many times as long as thick, and several times as long as the stigmal vein, which is short; basal vein represented by a thick oblique brown line. Petiole of abdomen slender, about three times as long as wide, with four dorsal carinae; body of abdomen not raised from the petiole, ovate, terminating in a sharp point, fully three times as long as its greatest width; segment 2 (first body segment) fully twice as long as the remainder combined, smooth, without grooves

or striae at base; 3 and 4 transverse, with minute punctures; 5 rather longer than 3 and 4 combined, near its base with a transverse row of several very long setae; 6 almost as long as 5, with several long setae.

♂. Resembling the female, but the abdomen is shorter, its segments 3-6 much shorter, 2 occupying four-fifths of its length. Antennae somewhat considerably longer than the body, dusky, the first three joints reddish; scape moderately long; pedicel less than twice as long as its greatest width; funicle 1 a little shorter and narrower than the pedicel; 2 almost four times as long as 1 and about as long as the scape, very feebly excised on one margin at one-half its length; 3-11 very slightly and gradually decreasing in length.

Habitat.—North Queensland: Cairns district, four females, three males, taken in August around a rotten log in the jungle, A. P. Dodd.

Type in South Australian Museum; cotypes in the South Australian Museum and the author's collection.

Propentapria consimilis, n. sp.

♀. Length, 3-3·5 mm. Strikingly similar to *venusta*, but the colour of the thorax is darker, the sides and venter and the propodeum and the petiole of the abdomen verging to black; femora and tibiae more or less dusky. Foveate area at base of scutellum not oval, but the posterior margin is concave, about four times as wide as long, the appearance of a subdivided fovea being practically lost and appearing more truly as five distinct foveae; propodeum more distinctly rugose, the carinae or rugae more oblique than in *venusta*. Venation terminating a little before one-half of the wing length, the marginal vein much shorter, about one-sixth or one-seventh as long as the submarginal and about three times as long as the short stigmal vein, the basal vein faint. Base of second abdominal segment with several shallow impressions. Pedicel of antennae rather longer than in *venusta*, the second funicle joint plainly shorter than the first (not noticeably so in *venusta*).

♂. Antennae no longer than the body; black, the first three joints red; scape long and slender; pedicel hardly twice as long as its greatest width; funicle 1 narrower than, but as long as, the pedicel; 2 two-thirds longer than 1, not one-half as long as the scape; 3-10 very slightly and gradually decreasing in length.

Habitat.—South Queensland: Mt. Tambourine, 2,000 feet, a large series in February, collected on leaves in the jungle.

Type in South Australian Museum; cotypes in the South Australian and Queensland Museums and the author's collection.

The differences in the antennal structure will readily separate the males of these two species, while the females may be distinguished by the different lengths of the marginal vein, and the shape of the foveate area at the base of the scutellum.

A REVISION OF CERTAIN AUSTRALIAN CHENOPODIACEAE.

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Botanic Gardens, Sydney.

(Plates xxv-xxvii.)

[Read 25th August, 1926.]

Introductory.

In my revision of the Australian species of the genus *Bassia* (PROC. LINN. SOC. N.S.W., xlviii, 1923, 354) two species, *Bassia tricornis* (Benth.) F.v.M. and *Bassia enchylaenoides* F.v.M. were excluded from that genus, as the characters of their fruiting perianths appeared to differ greatly from the general *Bassia* type.

Subsequently a critical examination was made of these two species, the present paper embodying the results of these researches.

A new genus is proposd for the one species, *Bassia tricornis* (Benth.) F.v.M., and the other species, *Bassia enchylaenoides* F.v.M., has been transferred to the genus *Kochia*.

A new species of *Kochia* is described, the material of which in the National Herbarium was previously included under *Bassia enchylaenoides* F.v.M. and *Kochia ciliata* F.v.M.

MALACOCERA, n. gen.

Flores bisexuales et foeminei, axillares. Stamina 3-5. Styli 2-3 ad basim breviter connati. Perianthium depressum globosum, tomentosum, 5 lobum, 3-5 obtusis horizontalibus mollibus cornuis ornatum. Perianthium fructiferum depressum, lanatum, non induratum, cornuis 3-5 cylindraceis mollibus dense tomentosis ornatum. Semen horizontale. Embryo annularis.

Fruticuli erecti et decumbentes. Folia alterna, sessilia, linearia v lanceolata. Flores minuti, solitarii, sessiles.

MALACOCERA TRICORNIS (Benth.), n. comb. Plate xxv.

Vide descriptionem generis.

A small shrub, the whole plant densely tomentose or hirsute. Leaves linear to linear-lanceolate, 5-15 mm. long. Fruiting perianth small, depressed, thin in texture, with 3 dorsal soft densely tomentose radiating horns. The tube of the fruiting perianth is quite small, the horns being from 3-6 times as long as it, and the base of the horns occupying the whole depth of the perianth tube.

The fruiting perianth remains unhardened to any extent.

Synonyms: *Chenolea tricornis* Benth., *B. Fl.*, v, 190.—*Bassia tricornis* (Benth.) F.v.M., *First Census*, 1882.

The species was first described by Bentham, who placed it in the genus *Chenolea*, including also in that genus five other species, namely: *Chenolea carnosa*

Benth., *C. Dallachyana* Benth., *C. eurotioides* F.v.M., *C. Muelleri* Benth. and *C. sclerolaenoides* F.v.M.

Under the genus *Chenolea* Bentham also included the genera *Echinopsilon* Moq. and *Eriochiton* F.v.M. pointing out that the development of the perianth spines was so vague that it was hopeless to distinguish between the genera. Later all the species of *Chenolea* mentioned above were placed by Mueller (First Census, 1882) in the genus *Bassia.*

In my revision of the genus *Bassia* all these species were retained in that genus, with the exception of *Chenolea tricornis* and *Chenolea carnosa.* The latter species was transferred to *Kochia.*

Chenolea tricornis Benth., although included by Mueller as a *Bassia* species in the First Census, has not the general characteristics of that genus. It differs mainly in the practically unhardened fruiting perianth and in the absence of all hard spiny appendages, these being replaced by soft cylindrical radiating horns. The fruiting perianths of *Bassia* species, on the other hand, are more or less hardened and furnished with spines. Further, Bentham's original classification of the species as a *Chenolea* can hardly be adhered to, as that genus is now restricted to species which have no appendages to the fruiting perianths. As the nature of the appendages of the fruiting perianth forms a basis for generic distinction within the family, e.g., the wing expansion of *Kochia*, the spines of *Bassia*, and the absence of appendages in *Chenolea*, it would appear that the peculiar and unique character of the perianth appendages of this species justifies the erection of a separate genus. Failing this course the species is extremely difficult to place with any degree of satisfaction.

The figure of the species in the "Iconography of Australian Salsolaceous Plants", Plate lxiii, under *Bassia tricornis* (Benth.) F.v.M. is reproduced here (Plate xxv). In this plate, perianths with four and five horns are shown, but in all the specimens seen by me the horns are strictly 3 in number.

Distribution.—The species occurs in South Australia, Victoria and New South Wales and is restricted to the arid portions of the interior. In the National Herbarium, Sydney, specimens are represented from Mt. Lyndhurst (Max Koch), Cockburn (A. Morris), Yandama (C. Collier).

KOCHIA CRASSILOBA, n. sp. Plate xxvi.

Section *Duriala.*

Fruticulus humilis villosus, foliis lineari-lanceolatis acutis 5-15 mm. longis, floribus solitariis, calyce fructifero 4-6 mm. diametro in lobos 5 crassos imbricatos aliquantum auriculatos producto, tubo calycis distincte costato, semine horizontali.

A dwarf undershrub, the whole plant usually villose, but occasionally almost glabrous. Stems prostrate or ascending. Leaves linear or linear-lanceolate. Fruiting perianth with 5 thickened, scarcely succulent, imbricate somewhat auriculate lobes, the tube of the fruiting perianth distinctly vertically 5-ribbed, and with 5 lesser intermediate ribs. Seed horizontal, enclosed in the perianth.

***Synonyms*: *Heterochlamys villosa* F.v.M., Second General Report of the Government Botanist, Victoria, 1854, p. 15.—*Enchylaena villosa* F.v.M., *Trans. Phil. Instit. Vict.*, ii, 1858, 76.—*Chenolea enchylaenoides* F.v.M., *Fragm.*, x, 92.—*Bassia enchylaenoides* F.v.M., *First Census*, 1882.**

As can be seen from the above synonymy this species has had an involved history, and its transference to yet another genus, together with the erection of a new specific name, would appear to add a further difficulty to an already

complicated position. This course has been followed reluctantly, but investigation made it appear unavoidable.

The species was first referred to by Mueller (Sec. Gen. Rep., 1854, p. 15) where it appears as a nomen nudum, *Heterochlamys villosa*. It was first described by Mueller (*Trans. Phil. Instit. Vict.*, ii, 1858, 76) as *Enchylaena villosa* and was placed under a separate section, *Heterochlamys*. Mueller, therefore, in the first place, apparently regarded this species as being generically, or at least sectionally, distinct, from other species of the family.

In confirmation of this it may be stated that in the *Native Plants of Victoria* (1879, 152), he again refers to this species as deserving a sectional or perhaps generic separation as *Heterochlamys*.

In *Fragm.* (x, 92), Mueller redescribes it as *Chenolea enchylaenoides*, and, finally, in the First Census (1882) he places it under *Bassia*.

Bentham (*Flora Aust.*, v, 182) describes the species under *Enchylaena villosa* F.v.M., but remarks that "it connects in some measure *Enchylaena* with *Kochia*, for the transverse thickening of the perianth lobes may be regarded as an incipient wing".

It therefore seems apparent that the botanists dealing with this species have experienced difficulty in placing it satisfactorily from a generic point of view.

An examination of the specimens in the National Herbarium, Sydney, which were labelled *Bassia enchylaenoides* F.v.M. (or *Enchylaena villosa* F.v.M.) revealed that two quite distinct species were involved:

(1) A species which is described later in this paper as *Kochia pentagona*, n. sp. (2) The true *Bassia enchylaenoides* F.v.M.

The most outstanding characteristic of the latter species is the peculiar, thickened, imbricate and somewhat auriculate lobes of the fruiting perianth. Both in Mueller's original description of the species and in Bentham's description, this characteristic is but vaguely referred to. Mueller, however, describes this feature both in the *Native Plants of Victoria* and in *Fragm.*, x, 92.

The figure in the *Iconography of Salsolaceous Plants* (Plate lxxxiv) shows no trace of this lobing and appears to be a different species.

It seemed possible, therefore, that our conception of the true *Bassia enchylaenoides* F.v.M. might be incorrect. To test this, the Bacchus Marsh type specimen (referred to in *Trans. Phil. Instit. Vict.*, ii, 76) was secured from the Melbourne National Herbarium. It was found to be identical with our specimens, showing clearly the peculiar lobing of the fruiting perianth. The nature of the fruiting perianth excludes the species from the genera *Chenolea*, *Bassia* and *Enchylaena*.

The fruiting perianth in *Chenolea* has no appendage; in *Bassia* it is provided with a varying number of spines, and in *Enchylaena* is succulent without appendages.

As the species clearly did not fall within any of the above mentioned genera, the course suggested itself of taking up Mueller's generic name of *Heterochlamys* and of following out his original intention by establishing a separate genus.

Two considerations were against this:—

Firstly, the name *Heterochlamys* is already occupied by a genus in the Euphorbiaceae, and, although this has been sunk under *Julocroton* as a synonym, the rules of nomenclature definitely state that it would be unwise to take the name up for a genus in the Chenopodiaceae. Secondly, the fruiting perianth of the species has many points of resemblance to some species of *Kochia*.

The peculiar overlapping lobes of the perianth are similar to those of the horizontal wing expansions of *Kochia oppositifolia* F.v.M., except that in the one they are thickened and more or less succulent and in the other they are membranous. The tube of the fruiting perianth, especially in regard to its ribbing, is very similar to that of *Kochia brevifolia* R. Br.

Taking these points into consideration it would seem best to regard the species as a *Kochia* species in which the wing expansions have become thickened and perhaps slightly succulent. Usually the wing expansions of *Kochia* species are membranous, but the genus already contains at least one species in which the lobes have become hardened, i.e., *Kochia lobiflora* F.v.M., and it does not seem to stretch the limitations of the genus too far to include a species with the thickened lobes or wings of *Bassia enchylaenoides*.

Bentham, as mentioned previously, also regarded this species as a transition form between *Enchylaena* and *Kochia*.

The only other course is to erect a new genus, but the characters do not altogether justify a generic distinction, and certainly the characters come very close to those of the genus *Kochia*. I therefore propose placing the species under *Kochia*, but at the same time giving it a sectional rank which may conveniently be raised to generic rank should this course appear desirable.

The question of what specific name should be adopted is a difficult one. *Villosa* is the name that should be taken up, but this would make a species, *Kochia villosa*, which would lead to endless confusion with *Kochia villosa* Lindl., which, although rightly reduced by J. M. Black as a synonym under *Kochia tomentosa* (Moq.) F.v.M., is very frequently credited with specific rank. Moreover the *Kochia tomentosa*-*Kochia villosa* group is so complex that future investigations might result in the taking up of the name *villosa* in application to a portion of the group. The other name, *enchylaenoides*, which has been used in connection with this species is a very suitable one but the name is already occupied by *Kochia tomentosa* (Moq.) F.v.M. var. *enchylaenoides* J. M. Black, and Mr. Black has informed me that he is raising his variety to specific rank.

It appears, therefore, that the only course to pursue is to give a new specific name to the species. The name *Kochia crassiloba* is therefore proposed.

Distribution.—The species is distributed fairly widely over the drier parts of New South Wales, Victoria and South Australia. The following localities are represented in the National Herbarium: Singleton (J. L. Boorman); Hermidale (A. Morris, No. 1287), Bogan Gate (E. H. Ising, No. 2104), Dubbo (E. Betche), Warrego River (E. Betche), Wanganella (Miss E. Officer), Mt. Ida (Mrs. E. Hill), Cobar (L. Abrahams), Goulburn River, Victoria (C. Walter), Murrayville, Victoria (H. B. Williamson), Woodville, South Australia (J. M. Black).

KOCHIA PENTAGONA, n. sp. Plate xxvii.

Fruticulus humilis, ramis tomentosis, foliis linearibus 6-18 mm. longis, 1 mm. latis villosis aetate nonnunquam glabrescentibus, floribus in axilibus foliorum solitariis, stylis 2, perianthio fructifero dense tomentoso 3-5 mm. diametro plus minus ve indurato, superne appendicem erectam crassam 5 angulatam concavam gerente, ala parvissima vel absente, semine horizontale.

Trangie, A. Morris, No. 1288, 16.10.24.

A small rather weak under-shrub with trailing or somewhat ascending tomentose branches. The fruiting perianth of this species is very characteristic, being densely woolly tomentose and produced dorsally to form a thick, vertical,

regularly five-angled or five-sided appendage which is more or less hollow in the centre and enclosing the rather long somewhat acute lobes of the perianth.

In some specimens there appears to be a very slight suggestion of a horizontal wing expansion, but this is completely absent in others.

This species had been previously labelled as either *Bassia enchylaenoides* F.v.M. or *Kochia ciliata* F.v.M., but the character of its fruiting perianth is quite different from either of those species.

J. M. Black (*Proc. Roy. Soc. S. Aust.*, 41, 1917, 43) has clearly defined the true *Kochia ciliata* F.v.M., and separates from that species a new species which he has named *Kochia coronata*. *Kochia pentagona* approaches *Kochia coronata* more closely than *Kochia ciliata* as the thick vertical 5-angled appendage of the perianth corresponds in position to the "crown" of thin vertical annular appendage of *Kochia coronata*. The absence of definite wing development in *Kochia pentagona* makes it difficult to place the species satisfactorily from a generic point of view. However there appears to be an incipient wing development in some specimens and the species falls most naturally within the genus *Kochia*. To some extent it forms a connecting link with *Bassia brachyptera* (F.v.M.) R. H. Anderson between the two genera.

Distribution.—Limited to the drier parts of South Australia, Victoria and New South Wales. Stock owners who have forwarded the plant for identification refer to it as a valuable fodder in dry districts. The following additional localities are represented in the National Herbarium:—

Nevertire (E. Betche), Nyngan (J. L. Boorman), Condobolin Flats (J. H. Maiden), Jerilderie (Bishop Dwyer), Hay (F. Fischer), Wanganella (Miss E. Officer), Booroorban (F. Fischer), Euabalong (J. L. Boorman), Mildura, Victoria (H. B. Williamson), Unstated locality in Victoria (C. Walter), Renmark, South Australia (J. M. Black).

EXPLANATION OF PLATES XXV-XXVII.

Plate xxv.

Malacocera tricornis (Benth.), n. comb. After Mueller, *Iconogr. Aust. Salsol. Plants*, Plate lxiii.

Plate xxvi.

Kochia crassiloba, n. sp.

Plate xxvii.

Kochia pentagona, n. sp.

STRATIGRAPHICAL AND STRUCTURAL GEOLOGY OF THE CARBONIFEROUS ROCKS IN THE MT. MIRANNIE AND MT. DYRRING DISTRICTS, NEAR SINGLETON, N.S.W.

By G. D. OSBORNE, B.Sc., Linnean Macleay Fellow of the Society in Geology.

(Plate xxviii; five Text-figures.)

[Read 28th July, 1926.]

Introduction.

This paper describes the structure and stratigraphy of the Carboniferous rocks along a belt about six miles wide between Glendonbrook and the neighbourhood of Glennie's Creek, in the Singleton district. This area is portion of the important Carboniferous belt of north-eastern New South Wales, which flanks the western and south-western margin of the New England plateau, and, passing north of Maitland, continues to the east coast of New South Wales in the neighbourhood of Port Stephens and the Manning River.

The Carboniferous areas close to Maitland, between Clarencetown and the Tangorin-Elderslie district, have been investigated in great detail, the eastern portion of this region having been described in full by the writer (Osborne, 1922, 1925). The general geology of the northern end of the Carboniferous belt has been described by Professor Benson (1913, 1917). The intervening area, between Werris Creek and Singleton, has in the past received little attention from geologists. In describing some of the general features of the geology and physiography of the Upper Hunter district, W. R. Browne (1924) has referred to certain structural features along this belt.

A. B. Walkom (1913), when examining the Cranky Corner basin of Permian rocks near Glendonbrook, made certain observations upon the Carboniferous rocks which surround the basin, and indicated on his geological map certain structural and lithological features. Nothing of a detailed nature, however, was done. In 1904 a description was given by Mingaye (1904) of portions of a meteorite obtained from the Mt. Dyrring district.

Apart from these articles no geological information about the region exists, excepting, of course, the incidental mention of certain portions of the district in comprehensive reports dealing with the Hunter district or eastern New South Wales as a whole.

The present writer made preliminary excursions across the Carboniferous belt between Singleton and Scone during 1922-1924, and in 1925 conducted some reconnaissance surveys with a view of obtaining a general idea of the structure of the area. Subsequently, detailed mapping was carried out during a period of about two months, and the map accompanying this paper (Plate xxviii) embodies

the results of this work. Along the belt from the neighbourhood of Lamb's Valley to at least as far north as Murrurundi, the junction between the Carboniferous and Permian is the line of a grand fault or fault zone. This line represents the southern and western margin of the area mapped, while in the directions of north and east the work was carried only so far as it was necessary to obtain a proper understanding of the structure and stratigraphy.

Acknowledgments.—The writer wishes to record his appreciation of the hospitality and kindness which he received from the local residents during his trips to the area. In particular, he would mention the kindness of Mrs. J. J. Graham and family of Sedgefield, Mr. F. Drinan and family of Glendonbrook, Mr. Milton Bailey and family of "Greylands", Mr. E. Moore and family and Mr. H. Moore and family of Westbrook, Mr. C. A. Clarke and family of Westbrook, Mr. R. H. Baker of "Benvenue" and Mrs. A. Roberts and family of Glendonbrook.

Also he is very grateful to Mr. and Mrs. L. B. Fisher, of "Brandon", Seaham, who in many ways helped to make the carrying out of the work a success, and to Mr. W. J. Enright, B.A., he is thankful for his kind interest and readiness to make helpful suggestions about the carrying out of the field work.

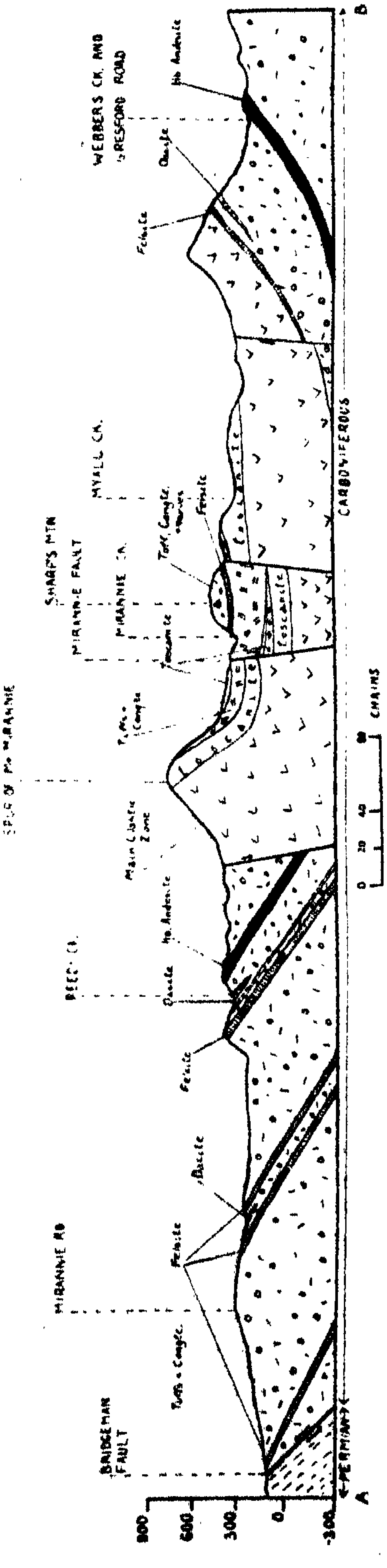
Further the writer wishes to record his indebtedness to Professor L. A. Cotton and Assistant-Professor W. R. Browne for having accompanied him and discussed many of the problems in the field, and especially to the latter for his helpful advice and criticism of the work during its progress.

Stratigraphy.

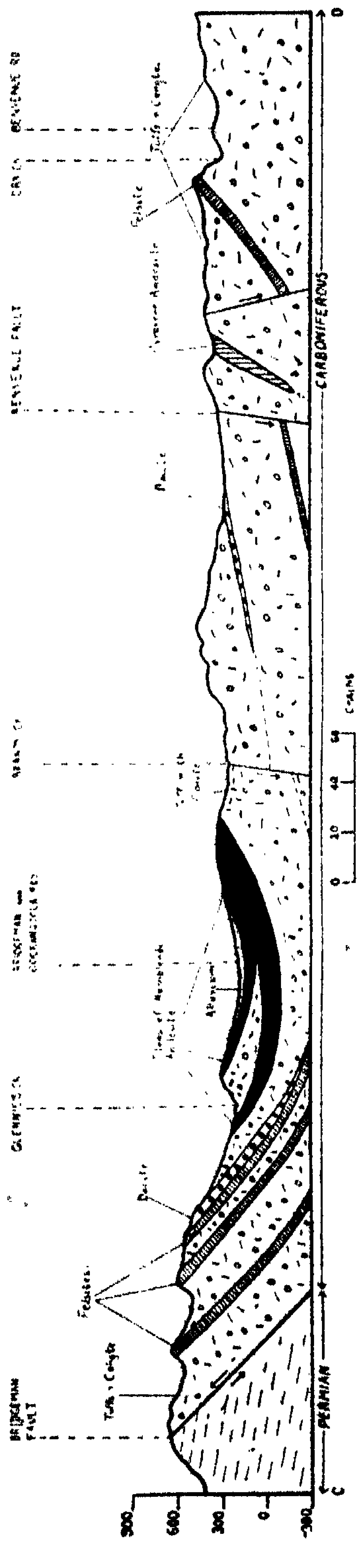
The Carboniferous rocks examined belong entirely to the Kuttung Series, and, as in the areas near Maitland, there is developed a series of lavas associated with tuffs, tuffaceous sandstones and conglomerates, and glacial deposits. During the work in the field it was soon recognized that there was a marked difference between the lithology of the tuffs and conglomerates associated with the main series of lavas, and those which follow these lavas and underlie the lavas of a general toscanitic or dellenitic character (Paterson type), which may be regarded as constituting a subsidiary series of flows. The second set of conglomerates and tuffs, just mentioned, attains to a maximum thickness of 1,200 feet, and is free from any associated lavas. They are the equivalent of the lower portion of the Glacial Stage of the Paterson district (Mt. Johnstone Beds of C. A. Sussmilch), and in this paper it is proposed to refer to them as the Main Clastic Zone.

The three sections (Text-figs. 3-5) described below comprise one through the Main Clastic Zone and two through the main series of lavas and associated clastic rocks.

Regarding the lavas which are present in the area, it is necessary to point out that, apart from the pyroxene- and hornblende-andesites, the toscanites and dellenites, and the dacites, there are a large number of rocks of a general light colour, which are felsitic in character, although possessing at times a certain amount of phenocrystic felspar. The true identity and relationship of these rocks do not concern us in the present paper and will be dealt with when the petrography is being recorded, but for the purposes of this report, the general name, felsite, has been given to the rocks, and thus they are indicated by a uniform marking upon the map. In order to individualize some of the more important of these flows certain locality names have been given.



Text-fig. 1.—Section A-B on map.



Text-fig. 2.—Section C-D on map.

The Bridgeman Section (C-D on map, Text-fig. 2).

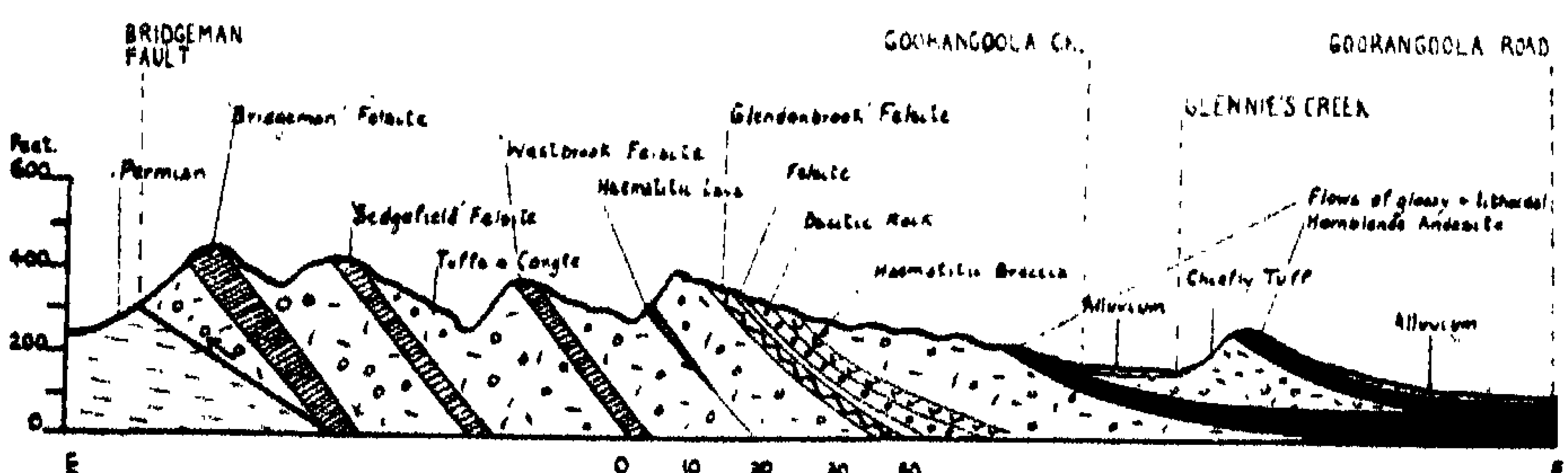
This section is seen in the western portion of the area, west of "Bridgeman". On the lowland to the east of the Goorangoola-Glennie's Creek road there are conglomerates, sandstones and gravels of the Permian system. These dip at no great angle towards the east and are soon cut off by the Bridgeman fault. The lowest members of the Carboniferous rocks then succeeding are coarse conglomerates. The boulders in these attain a maximum diameter of four feet, and consist chiefly of red granite, quartz-porphyry and banded rhyolite. A very rich soil is derived from the matrix of these conglomerates; they are overlain by the Bridgeman felsite which is dipping at about 40 degrees. The rock is generally fawn in colour but sometimes darker, and possesses some red phenocrysts of felspar in a fine felsitic groundmass. Following the felsite comes more conglomerate and tuff. This type of deposit is very common throughout the area and, except for a variation in the size of the constituent pebbles, does not show much change in general characteristics. The boulders comprise chiefly acid felsitic and porphyritic rocks, aplitic and granitic types and fine-grained siliceous units. The matrix is fairly coarse and ferruginous and possesses a light salmon colour. Current bedding is noticeable in the finer layers of sediment and also in those strata which, on careful examination, prove to be tuffaceous sandstones and grits. The conglomerate is next overlain by the Sedgefield felsite which is very similar to the Bridgeman felsite in lithological character. Conglomerates now follow and the section descends into a creek where a fine section of the conglomerate shows its coarse nature here. On top of the conglomerate and tuff is the Westbrook felsite which is slightly more strongly porphyritic in felspar than the foregoing felsites. Like the previous members it dips steeply, and also possesses a number of cracks or joints which may have developed during cooling. This felsite is succeeded by more conglomerate in which a thin band of haematitic lava occurs. The rock in this case is very decomposed and the haematite occurs in strings and patches set in a lithoidal groundmass. The conglomerate is succeeded by a number of thin flows whose angle of dip is greater than the slope of the ground and hence they outcrop in narrow bands. The first lava is the Glendonbrook felsite which has a characteristic appearance. It is of a lavender colour, felsitic in nature with a few fawn felspar phenocrysts, and it weathers in a blotchy manner. It also exhibits a characteristic hackly fracture. It is overlain by a mauve-coloured felsite with red felspars set in a rough-feeling felsitic groundmass. This unit is very thin and is soon succeeded by an interesting dacite. Here the rock is not massive, but possesses streaks of glassy material associated with the main bulk of the rock which is lithoidal in appearance and cryptocrystalline. Biotite is fairly important in this rock and haematite is quite abundant. The variation of the horizon elsewhere will be noted later. Overlying the dacite is a haematitic breccia which may represent the accumulation of coarse fragments of tuff showered into the molten lava which has solidified to form the matrix of the rock. Here the rocks are dipping more gently and after passing over more tuffaceous conglomerate one reaches the flows of the hornblende andesite (Martin's Creek type). These vary in colour and nature, there being some dark varieties which are very much altered, also some blue phases which are only slightly altered and some completely albitized types. Intercalated with the flows is a wedge of tuffaceous conglomerate. The andesites represent the highest members of the main volcanic series in this section.

The thicknesses of the beds and a summary of the section are as follow:

	Feet.
Conglomerate and tuff	60
Bridgeman felsite	40
Conglomerate, tuffs and tuffaceous sandstone	150
Sedgefield felsite	30
Conglomerate, etc.	220
Westbrook felsite	30
Conglomerate with haematitic lava band	250
Glendonbrook felsite	20
Lavender felsite	15
Dacite with glassy streaks	30
Haematitic flow-breccia	20
Conglomerate, etc.	170
Hornblende andesite	50
Conglomerate and tuff	150
Hornblende andesite flows	200
TOTAL	1,435

The Dyrring Section (G-H on map, Text-fig. 3).

The interest in this section lies in the occurrence of the pyroxene-andesite. This is present as a number of thin flows and its stratigraphical position is lower than any of the rocks of the Bridgeman section. Succeeding the andesite which outcrops on the northern fall of the ridge at the head of Mundawah Creek there is the typical conglomerate and tuff so prevalent throughout the area. Then comes a series of lavas beginning with a brownish-green rock, fairly strongly porphyritic in fawn felspars. In places the rock contains many angular fragments of decomposed igneous rocks, but nevertheless it is essentially a lava. Following this is a



Text-fig. 3.—Section E-F on map.

thin band of a purplish rock which possesses a hackly fracture and phenocrysts of albite. Immediately on the surface of this there is another lava of a light colour, which contains pink felspar individuals set in a dense felsitic groundmass. Succeeding this there is conglomerate, in which the boulders are of a considerable size, and then the Sedgefield felsite which here is of a darker colour than usual, and which also shows the presence of fewer phenocrysts than elsewhere. The conglomerate which follows the felsite is quite thick and is characterized by the presence of a very easily eroded matrix so that dissection has been rapid. This conglomerate is eventually overlain by the Westbrook felsite which shows up very well physiographically. The rock is fawn in colour here and in places is strongly jointed. Immediately on top of the felsite there is a coarse tuff which does not persist very far in the direction of strike, and is followed by a thin

local flow of dacite, which possesses a brownish colour and appears to represent a devitrified glass. The lavas hereabouts are not very well developed, thinning out rather rapidly. The next flow, after the intervention of some tuff and conglomerate, is a lavender rock, the Glendonbrook felsite. It is poorly developed and is overlain by conglomerate and tuffaceous sandstone; these in turn are overlain by a flow of lithoidal dacite which, like a former dacite, seems to be a devitrified rock. Following the dacite there is more conglomerate, the pebbles in which do not exceed about six inches in average diameter. These sediments pass under a series of flows of hornblende-andesite (Martin's Creek type). It is interesting to examine the flows here, because one can see the effect upon them of the operation of magmatic solutions. Some of the flows have been converted into phases which are fawn in colour and have the felspars completely albitized and altogether appear very similar to many of the felsites lower down in the sequence. Some of the altered andesite is very different from the unaltered rock and only by tracing the altered rock along to its contact with the unaltered rock could one be convinced that the two originally were the same. Some of the phases are fine grained and almost devoid of visible phenocrysts.

These andesites are just about at the top of the main volcanic series and are followed by the rocks of the Main Clastic Zone. The summary of the Dyrring Section is as follows:

	Feet.
Conglomerate	50
Pyroxene-andesite flows	100
Felsite	20
Felsite	30
Felsite	20
Conglomerate and tuff	60
Sedgefield felsite	50
Coarse conglomerate and tuff	400
Westbrook felsite	50
Coarse tuff	30
Dacite	30
Conglomerate, etc.	150
Glendonbrook felsite	30
Conglomerate	50
Dacite	30
Tuffaceous conglomerate	350
Flows of hornblende andesite sometimes altered	150
TOTAL	1,600

Other Areas of Stratigraphical Importance.

It would be impracticable to describe all the small occurrences of lavas and tuff throughout the area, but there are some localities where there are interesting sections, and these may now be considered.

Near the junction of the Glennie's Creek and Goorangoola roads, there are some masses of a purple-coloured breccia which does not conform in general disposition to the associated lavas and sediments. With the breccia is found a massive rock of the nature of a felsite. The exact mode of occurrence of these rocks is unknown but, from a consideration of their strikes, it is possible that they may be intrusive.

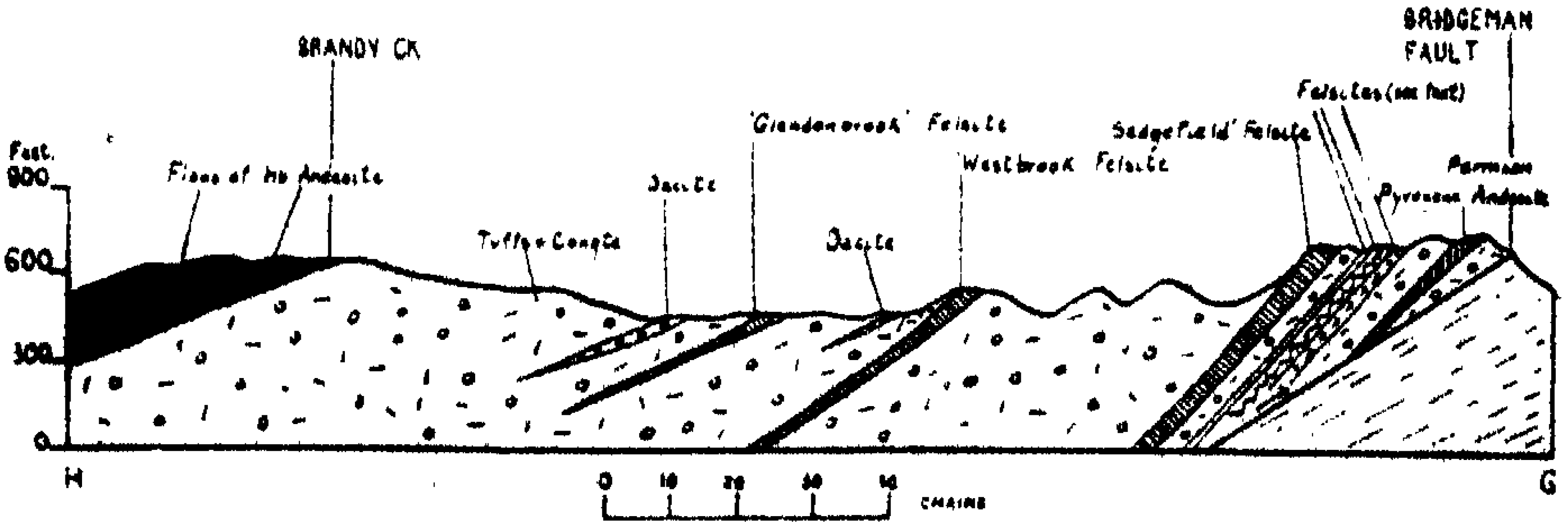
Along the zone of the Bridgeman fault between the head of Mundawah Creek and "Spottiswoode" homestead, and also in the vicinity of the cross-road connecting the Gresford road with the Mirannie road, there are many outcrops of felsite. Some

of these are similar in general respects to the more important felsites described above, but some of them are of further interest in possessing notable amounts of biotite. Many of these felsites are strongly jointed and an examination of the associated strata shows the absence of any such jointing. The direction of the jointing is always about the same with reference to the upper or lower surface of the flows, and hence it is probable that the jointing had its origin during the cooling of the rocks. Some of the lavender-coloured felsites show flow lines but this feature is not very common.

Just to the east and also to the west of the Westbrook Public School and again in the bed of West Brook a little to the south of the school, there are numbers of outcrops of felsitic and dacitic rocks, which possess some stratigraphical interest. In the creek we find an intimate association of dacites and felsites, strongly porphyritic in red felspars. The beds appear to dip toward the north, but the succession is quite different from that obtaining in the areas further west which have been considered above. At Westbrook School there is a lavender felsite which occurs in the form of a shallow basin structure and is variable in appearance. It appears under the microscope to resemble both the Westbrook and the Glendonbrook felsites, but the area along the Westbrook road is so disturbed that there is some doubt as to the exact position of the rock in the stratigraphical succession.

Just west of the school there is a mass of andesitic rock which has weathered in such a way as to exhibit the appearance, when viewed a little way off, of a coarse breccia. This differential weathering, whereby some areas of the rock are bleached and decomposed and others are hard and relatively undecomposed, probably results from the fact that the rock has been affected in a partial manner by magmatic solutions.

In the northern part of the Parish of Marwood and to the north of Webber's Creek and Glendonbrook School there is a very interesting area where a number of small outcrops of lavas and tuffs occurs. These comprise dacitic and felsitic rocks, and the tuffs appear to be those of primary deposition. The best developed of the felsites is the Glendonbrook type, which, as elsewhere in the area, is of a characteristic lavender colour and contains few phenocrysts of felspar. The dacites are intimately associated with the felsites and the former are chiefly red



Text-fig. 4.—Section G-H on map.

in colour with a fair amount of biotite and glassy felspar. The red colour is due to the presence of haematite which has been discharged during the devitrification of a glassy rock.

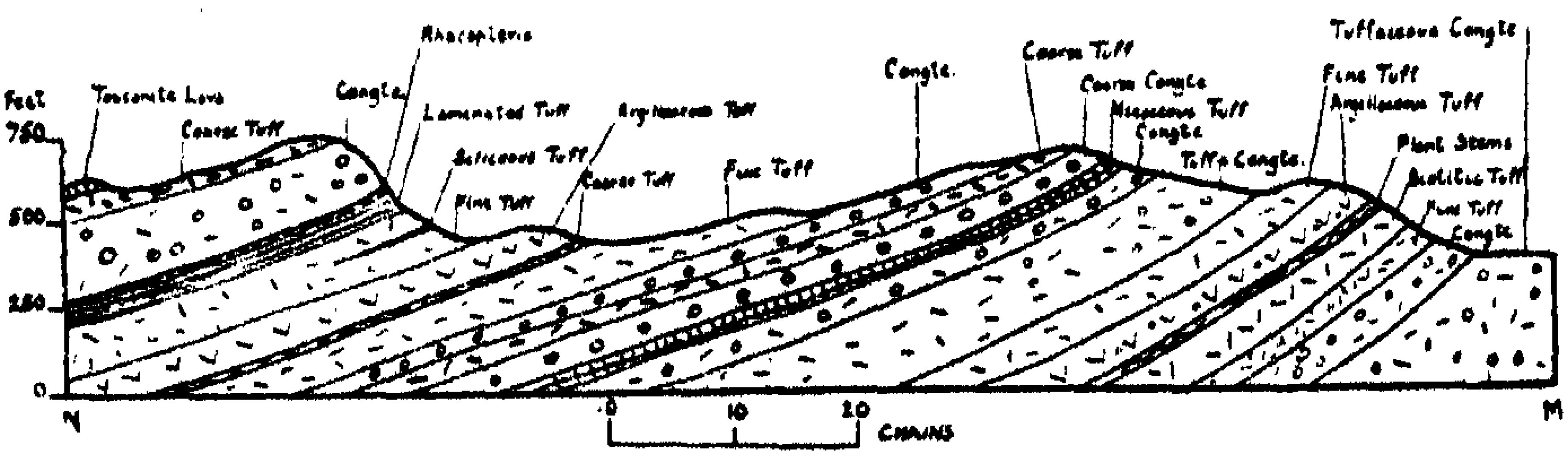
East of this area, towards the Cranky Corner road and particularly close to Webber's Creek, there are sporadic outcrops of dacitic rocks. Some of these are well exposed in the bed of Webber's Creek where they dip at high angles to the north. Just near the Roman Catholic Church below the Gresford road, in the bank of Webber's Creek, there is a fine section of the conglomerates and tuffs associated with the lavas. These are dipping steeply to the north and show current bedding and, in places, evidence of having accumulated rapidly.

In the extreme eastern portion of the area and also in two places on the western side of Mt. Mirannie, there are to be found small outcrops of felsitic lavas, which possess a higher stratigraphical position than the Martin's Creek type of andesite, being separated from this by a mass of tuffaceous conglomerate. These flows are the last of the main volcanic series.

In the conglomerate succeeding the hornblende-andesite, in a creek about one mile S.W. of Billy Brook, in the eastern portion of the area (see map), a discovery was made of some fine specimens of silicified plant stems. Dr. Walkom has kindly informed the writer that these fossils are examples of *Clepsydropsis australis*, a Zygopterid stem (see Sahni, *Ann. Bot.* xxxiii, 1919, 81), and they are of great interest on account of their rarity in New South Wales, being recorded only once before, viz. from the New England district. The location of the fossil was such as to make it clear that it had not been carried by present-day stream action, since there was no sign of corrasion, and apparently it had become silicified while in the gravels, now exposed as conglomerate. The approximate stratigraphical horizon of this interesting occurrence is at least 2,000 feet above the base of the Kuttung Series, possibly more.

Stratigraphy of the Main Clastic Zone.

The Main Clastic Zone has been studied in a number of places and the section along M-N (Text-fig. 5), from the region to the east of Glendonbrook, gives the most information.



Text-fig. 5.—Section M-N on map.

Starting near Myall Creek upon the tuffaceous conglomerate which underlies the Main Clastic Zone, one first strikes conglomerate which possesses a lithology different from that of the underlying rocks. This is overlain by tuffs and conglomerates which vary a good deal as regards texture and constitution. Some of these are ferruginous, some are argillaceous, and in the case of the tuffs in particular, there are some arkosic types. Quartz crystals are often found in the tuffs and, indeed, some of the tuffs appear just like quartzites. Biotite is an important constituent in certain bands which are generally acidic in composition. Many of the tuffs in this section weather rather readily and give rise to mature topography, this being due to the fact that such units are dominantly argillaceous.

The conglomerates in the Main Clastic Zone are characterized by being less easily disintegrated than those associated with the main volcanic series. The constituent pebbles are chiefly of acid rocks, but there is an almost complete absence of the pink aplite pebbles which are so prevalent in the conglomerates under the section now being considered.

One of the most important features of the section is the occurrence of *Rhacopteris*. While plant stems and macerated plant remains are found in many places in the Main Clastic Zone, only one horizon has been discovered in this zone from which *Rhacopteris* may be obtained. This is about 400 feet below the top of the zone. The fossils are fairly well preserved in a fine cherty rock of a yellow or white colour. The exact succession along the line M-N and the thicknesses of the units are given in the following summary:

	Feet.
Basal conglomerate	50
Fine tuff	30
Tuff with biotite	30
Tuffaceous sandstone with plant stems	10
Argillaceous tuff	40
Fine grained tuff with ferruginous cement	40
Tuff and conglomerate	100
Coarse conglomerate	30
Micaceous tuff with pebbles	25
Coarse conglomerate	30
Coarse quartzose tuff	20
Conglomerate	20
Fine argillaceous tuff	200
Coarse tuff	20
Argillaceous tuff	50
Fine gritty tuff with pebbles	80
Siliceous tuff	20
Laminated tuff with macerated plant remains	50
Cherty rocks with *Rhacopteris*	10
Conglomerate	100
Coarse tuff	30
TOTAL	985

Toscanite and Dellenite and Associated Strata.

The rocks directly overlying the Main Clastic Zone are well developed in the Mt. Mirannie region, where there is a large area of the toscanites and succeeding strata. These lavas are quite distinct from the lavas lower down and already described. There are at least two flows, perhaps more, and there are quite a number of phases of toscanite and dellenite, although the variation is not very marked in hand-specimen. To the west of Mirannie Creek the sequence may be examined to advantage. Here there are two flows of toscanite, rich in hornblende. The first of these is the more important and caps the spur running south from Mt. Mirannie. It is overlain by tuff, which in places appears just like a massive lava, but which under the microscope is seen to be clastic. These tuffs have suffered no redistribution, although the whole of the tuff in this region is not of this nature. Some of the tuffs are strongly biotitic. The tuffs give place to the second unit of toscanite, which is thrown into a shallow plunging syncline. This second horizon of toscanite is not present on the eastern side of the Sharp's Mtn. ridge, but its absence is due to presence of a strike fault. The presence of the Mirannie fault causes a break in the stratigraphy, but there is no doubt that not more than 100 feet of strata are hidden from sight. Thus, allowing for this break

in the sequence, we see that the next beds are coarse and fine tuffs in alternation. In some of these plant stems have been found. The fine tuffs are very quartzose, while the coarser varieties are strongly ferruginous. Succeeding the clastic rocks is the Mirannie felsite which, stratigraphically, is the highest lava in the district. This felsite encircles Sharp's Mtn., and varies abruptly from place to place in thickness. Overlying the felsite is a series of clastic rocks, well exposed on the southern face of Sharp's Mtn., and comprising tuffs, conglomerates and some glacial beds. In the tuffs *Rhacopteris* has been found. The glacial beds are varve rocks and fluvioglacial conglomerates, and are only poorly developed. These glacial beds are the topmost units of the Kuttung Series in this district. The varves are greenish in colour and very hard in places as a result of silicification. They show some contortions, due to movement in the sediments before they became compacted. The fluvioglacial conglomerates are seen only in a few small gullies, and it is difficult to find many striated pebbles, but the lithology is that of a subglacial deposit.

A summary of the stratigraphy of the rocks following the Main Clastic Zone is as follows..

	Feet.
Dellenite-toscanite lava	200
Primary tuff	50
Pebbly tuff	80
Toscanite rich in hornblende	150
Slight Stratigraphical Break here.	
Red and white tuffs, quartzose in places	50
Mirannie felsite	50
Pebbly tuff	30
Coarse tuff	50
Fine tuff with *Rhacopteris*	25
Coarse biotitic tuff	46
Conglomerate	55
Coarse conglomerate with tuff bands	38
Rock like fine tillite	15
Fluvioglacial conglomerate	100
Varve rock	30
Fluvioglacial conglomerate and tuff	60
TOTAL	1,029

Brief Discussion of the Stratigraphy.

From the foregoing account the following general summary of the stratigraphy of the Kuttung Series may be obtained:

	Feet.
Main series of lavas, tuffs and associated clastic rocks	2,000
Main Clastic Zone	1,200
Second series of lavas, tuffs and associated clastic rocks, including glacial beds	1,029
TOTAL	4,229

It will be seen then, that, although the base of the Kuttung Series is not exposed, there is at least 4,200 feet of strata present in the area. To this must be added about 100 feet of material which has been cut out of the sequence by faulting in the neighbourhood of Mt. Mirannie. That is to say, about 4,500 feet of the Kuttung Series is exposed in the Mirannie-Dyrring region.

The salient features of the stratigraphy are as follow: Starting from the lowest beds exposed there is a series of lavas and tuffs and associated conglomerates, the last named possessing a very characteristic lithology. These lavas constitute the major of two volcanic series developed in the area. After the topmost lavas in this series there follows about 200 feet of the conglomerates, and then a series of clastic rocks with a lithology distinct from those just mentioned. These form the Main Clastic Zone. It is quite clear that these rocks have developed by the accumulation of material derived from areas distinct from those which provided the sediment for the clastic rocks associated with the lavas of the main volcanic series.

The fragmental rocks associated with the second volcanic series are somewhat like those of the Main Clastic Zone, but there is a greater proportion of quartzose tuffs. Then at the top of the Kuttung Series we have the glacial beds comprising varves and tillitic conglomerates, so that there is a change in lithology throughout the clastic rocks of the whole area.

Concerning the volcanic succession it is to be pointed out that a fair amount of variation in the order of the flows is evidenced from place to place, and that the only broad succession which holds for the whole region is as given here: Pyroxene-andesites, Bridgeman felsite, Sedgefield felsite, Westbrook felsite, Glendonbrook felsite, dacites, hornblende-andesites and felsites. Very little can be said regarding the relationships of the lavas, as no detailed petrographical work has been done, but it is to be noted that rocks of an intermediate character are found in the lowest position stratigraphically, and these are followed by very acid lavas until at the zone of the hornblende-andesites we have rocks of an acid-intermediate nature. These, again, are succeeded by acidic units.

In the second volcanic series, toscanites and dellenites of fairly acid character are found, and near Mirannie Creek these are associated with an acid felsite, the Mirannie felsite.

The relationship of the volcanic succession in this area to that in other areas will not be considered in this paper.

The presence of *Rhacopteris* on two horizons, one below, and the other above the Paterson toscanites, is of some interest. In the Paterson-Clarencetown areas the *Rhacopteris*-bearing strata were always found under the toscanites in the same relative position as that of the first horizon in this area. Elsewhere in the Carboniferous areas the writer has found two horizons, and it will doubtless be possible, when more detailed work is done, to use these horizons of *Rhacopteris*-bearing strata as useful stratigraphical indicators in areas where otherwise the stratigraphy would be obscure.

Rocks associated with the Kuttung Series.

There are very few rocks other than those of the Kuttung Series in the area. South of Mt. Mirannie, near the boundary of the Parishes of Marwood and Mirannie, and on the right bank of Mirannie Creek there is a dyke of dolerite which extends for about five chains in a north and south direction. The dolerite is in association with a fine-grained basaltic rock which may represent a chilled marginal facies. The dolerite is very fresh and is olivine bearing. There are no data to indicate the precise age of the dyke, but it is highly improbable that it is connected with the Carboniferous rocks, and indeed it might even be Tertiary in age.

North-east from this occurrence, on the line of the fault, F_2, east of Sharp's Mtn., there is a small plug of decomposed basalt. Also to the east of Westbrook

Post Office in a small wash-out there is a mass of decomposed material which suggests a dyke structure, but very little can be made out with reference to it.

To the west of "Spottiswoode", near Mundawah Creek, there is a small mass of a rock which has been basaltic but is now altered to an albitic rock. This is evidently present as a dyke and breaks through the surface very close to the Bridgeman fault, in such a way as to make it a matter of doubt whether the rock is directly associated with the Carboniferous or the Permian.

Salient Features of the Distribution of the Rocks.

An inspection of the map shows that the most persistent of all the lavas is the hornblende-andesite. This has proved of great help in mapping the structure of the area. It is not thick in any portion of the eastern areas, but in the neighbourhood of Bridgeman becomes of greater thickness. One finds in tracing along this unit that there is a variation in the general appearance and nature, and often the rock becomes dacitic on account of the presence of free quartz. There are both glassy and lithoidal phases of the andesite and, as is generally the case in the Lower Hunter district, the glassy varieties are to be found under the stony types.

The felsites increase in importance from east to west. The Bridgeman felsite does not persist as well as the Westbrook and Sedgefield felsites, while the Glendonbrook felsite occurs only intermittently throughout the area. There is a great variation in the appearance of the felsites, especially in the case of the Westbrook type. This may be well seen along the ridge running north-west from the Mirannie road near "Bogleburn" homestead. Along the strike there are some haematitized rocks, some which are silicified and others which are albitized. The felsites frequently occur in small masses, but, where outcropping for long distances, they show a remarkable constancy of thickness.

The dacites have in general a red colour and can be easily traced throughout the area. Most of the dacites are lithoidal in texture but in some places glassy varieties occur. Near Bridgeman there is a fair amount of dacite possessing glassy streaks, and elsewhere the rock becomes entirely glassy, thus being a pitchstone. As the main dacite near Bridgeman is traced west, the rock changes its character, becoming more and more devitrified.

The tuffs of the Main Clastic Zone are fairly uniform in their development and distribution. Large areas of these rocks are found surrounding the Mirannie Basin and flanking Mt. Dyrring. The conglomerate bands in the series are persistent and disintegrate slowly so that they stand out from the tuffs, and produce a ribbing of the surface. Of the two *Rhacopteris*-bearing horizons, the lower, stratigraphically, is the more widely distributed in the area.

The toscanites and dellenites are best developed in the area of the Mirannie basin. These flows are fairly constant in their chemical character, although there is, at times, a small but noticeable variation. On Mt. Dyrring there are at least two flows of the toscanites, but they are not so well developed as in the neighbourhood of Mt. Mirannie. Associated with the toscanites near Sharp's Mtn. is the Mirannie felsite which is very restricted in its distribution.

The highest units in the sequence are the glacial beds and associated conglomerates. These are poorly developed and occur only on Sharp's Mtn. and on Mt. Dyrring. The varve-rocks do not show much uniformity of thickness and in places they cut out altogether.

STRUCTURAL GEOLOGY.

General.

A glance at the geological map will show the presence of open folded structures resulting from cross-warping, and of much faulting throughout the area. Separating the Carboniferous rocks from those of the Permian system, from Glendonbrook to the north-west, is a line of major displacement, the Bridgeman fault. Near Glendonbrook the Webber's Creek fault (so named by Walkom, 1913) has in places brought the Carboniferous rocks of the area against those of the Stanhope-Tangorin province, while elsewhere it has placed them against the Permian of the Cranky Corner basin. The probable relation of the Bridgeman and Webber's Creek faults will be discussed later.

The fairly open nature of the folding is in keeping with most of that displayed by the rocks of the Hunter district. This folding affected both Carboniferous and Permian rocks and was of late Palaeozoic age. As a result of the folding there have been produced two basin structures—the Mirannie and the Bridgeman basins, and their complement, an irregular plunging anticline. It will be instructive to take each of these structures in turn.

The Mirannie Basin (see Text-fig. 1, p. 389).

The area around Mt. Mirannie and Sharp's Mtn. has been extensively faulted, but the presence of a basin is shown by the dips indicated around the base of Sharp's Mtn. The area at Sharp's Mtn. is really the central portion of the basin which extends to the east and west for a considerable distance. The semi-circular outcrop of the hornblende-andesite between Westbrook and "The Pass" on the Gresford road (see map), indicates approximately the southern half of the Mirannie Basin, but the behaviour of the beds to the north of Mirannie is not known in any great detail, except that some of the units definitely dip towards the south and form a closed structure.

The toscanite which forms so much of the central portion of the basin, dips rather steeply on the western side of Mt. Mirannie, while near Myall Creek, on the east side, the dip is gentle and there is evidence for believing that there is an overlap of the tuffs, which follow the toscanite, on to the lower members of the series. The faulting on either side of Sharp's Mtn. has had the effect of preserving some of the glacial beds which are now found on the top of the ridge, while rocks in the same stratigraphical position have been eroded from the slopes of Mt. Mirannie. Sharp's Mtn., while being the centre of a basin structure, is also a small senkungsfeld.

The Bridgeman Basin.

This structure occurs in the western portion of the area, and is clearly delineated on the map by the outcrops of the hornblende-andesite flows which occur at Bridgeman. The road to Mt. Royal and the Goorangoola road join within the basin, and in traversing either road in the neighbourhood of Mt. Olive the geologist is soon aware of the presence of a very interesting basin structure. The beds on either side of the basin show unequal development, there being a mass of tuff and conglomerate intercalated with the andesite on the western side which does not occur on the eastern side. In contrast with the Mirannie basin there are no high dips. On the western side the angle of dip is about 25 degrees and on the eastern side about 17 degrees.

The eastern margin of the basin is marked by a fault, F_1, and to the east of this the beds change their direction of dip abruptly. This produces an interesting physiographic feature to be mentioned later.

North of Bridgeman the tuffs and lavas which underlie the hornblende-andesite dip south for some distance, but soon the dip is reversed and there is evidence of more broad folding.

The Plunging Anticline.

Linking the Bridgeman and Mirannie basins there is an area where the rocks do not show very much warping, although the dips are high, but examination of the directions of dip shows the presence of a very irregular plunging anticline. This structure is complementary to the two basins and is broken by some heavy faults.

Section A-B (Text-fig. 1, p. 389).

In the neighbourhood of "Spottiswoode" homestead good sections of the Upper Coal Measures may be seen in West Brook. When the Bridgeman fault line is crossed the Carboniferous rocks appear, consisting of series of felsites and conglomerates dipping to the north-east, until, near Reedy Creek, on its left bank, the Martin's Creek type of hornblende-andesite is encountered, dipping N. 25° E. at 30°. On top of this comes a fair amount of conglomerate similar to that which preceded it, but on the flat land to the east there is a change to the tuffs and well-cemented conglomerates of the Main Clastic Zone. These follow to within 80 feet of the top of a spur of Mt. Mirannie, over which the section now runs, where toscanite occurs dipping steeply towards Mirannie Creek. After passing over tuff and more toscanite, Mirannie fault and Mirannie Creek are crossed, and the central portion of the Mirannie basin is traversed along the ridge of Sharp's Mtn. On the eastern side of the ridge one passes a line of normal faulting and descends over toscanite into the rugged gorge of Myall Creek. Continuing to the east the Myall Creek road is crossed and once again the tuffs and conglomerate of the Main Clastic Zone are in evidence. Hereabouts there is undoubtedly some minor faulting but little can be determined concerning it. It is just about here also that the main horizon for *Rhacopteris* is to be seen, and then to the east of the Gresford road the base of the Main Clastic Zone occurs, and two thin felsitic lavas outcrop before the well-known hornblende-andesite is seen. This unit is dipping at an angle of 30° and is underlain to the east by the tuffaceous conglomerates so characteristically associated with the andesite throughout the area.

Section C-D (Text-fig. 2).

The section starts on the Permian conglomerates and tuffs which are probably representatives of the Upper Coal Measures, and a little to the east the Bridgeman fault is crossed. The rocks of the Kuttung Series now follow in a series of dip-slopes composed of conglomerates and acidic lavas, alternating with one another. At Glennie's Creek (or Fal Brook), the western margin of the central portion of the Bridgeman basin is reached, and here the dip of the beds has decreased. The basin is crossed chiefly along the alluvium which covers the centre of the depression, and the westerly dipping flows of hornblende-andesite, which occur east of the Mt. Royal road are then seen. Further east, near Brandy Creek, a fault occurs which separates the basin from the conglomerates which underlie it. Along the line of the section the dip is now flat and lavas are met with only occasionally, the rest of the strata being tuffs and conglomerate. Eventually a

north and south fault is reached near Dry Creek. This throws to the west and has associated with it much crushing and jointing of the strata, and a local steepening of the pyroxene-andesite which is found in the bed of Dry Creek dipping at an angle of about 70°. Beyond the pyroxene-andesite there is the Benvenue fault throwing to the south-east, and then comes conglomerate and a felsite, the presence of which has determined, in part, the course of Dry Creek. This felsite is one of the higher members of a section of stratigraphical interest which is described above (Text-fig. 4).

Faulting.

General Considerations.

From the geological map it will be seen that, in addition to the great fault separating the Carboniferous and Permian systems, there are a large number of comparatively smaller faults. The faults thus can be grouped into two classes as implied in the statement of the preceding paragraph. The Bridgeman fault, the only one to be found in the first class, appears to be an overthrust, while with the exception of the Webber's Creek fault, about which more will be said later, all the other faults appear to be of normal character.

The relation of the Bridgeman fault to the Webber's Creek fault is considered below, but its relation to the other normal faults is of great importance, and the consideration of this involves the consideration of the structure of the whole of the eastern side of the Hunter Valley between Maitland and Murrurundi. The present writer intends in the immediate future to continue his studies on the Carboniferous rocks to the north-north-west of the area now being discussed, and after examination of the northern areas of Kuttung rocks it will probably be possible to give a satisfactory account of the late Palaeozoic tectonic history of the area. In the present communication it need only be stated that the Bridgeman fault seems, without doubt, to belong to a later date than the other faults, because it is found truncating some of these, and also since it differs from these entirely as regards direction and nature.

Concerning the other faults collectively, it is seen that many of them are meridional in trend, while of the remainder the most important are of a general east-west trend. These faults are certainly normal in most cases, and probably so in the remainder, and in some instances the magnitude of the displacement along them is considerable. A consideration of the outcrops of the beds dislocated by some of the faults suggests that there has often been a certain amount of lateral movement. While no slickensided surfaces have been found in connection with the larger faults, still in a number of the smaller faults, these have been seen. Thus, near Mt. Dyrring, sub-horizontal slickensides were observed along planes in the rocks close to the faults, the planes being more or less parallel to the fault zones.

The age of the faulting is of great interest, especially in the case of the Bridgeman fault, but here again it is premature to make any definite statements. W. R. Browne, in describing the salient features of the geology of the Upper Hunter, made some remarks about the age of the Wingen fault (which may represent the same fracture line as the Bridgeman fault), and showed the possibility of that fault being post-Triassic and older than the Tertiary basalts of the Hunter district. He points out, however, that more detailed work is necessary.

Regarding the age of the normal faults one can point out that the faulting represented by them antedated the uplift in eastern New South Wales which

produced the existing highlands, because these faults do not show up physiographically and only indirectly control the evolution of the topography, by the arrangement of the strata which they have effected. The fact that the faults antedated the Kosciusko uplift, implies that they were developed prior to the peneplanation that preceded that uplift. The writer thinks it very probable that the faulting was connected with the diastrophism which produced the folding throughout the region. This folding was of a late Palaeozoic age.

Description of the Faults.

The Bridgeman Fault.

There is no lack of evidence of the existence of the Bridgeman fault throughout the area. A traverse along the boundary of the Carboniferous rocks shows that a faulted junction exists between these and the Permian rocks. The line of the fault may be definitely mapped and in no case was it necessary to speculate as to the position of this line. In some of the creeks one can almost find the outcrop of the fault surface, while in many places the two sets of strata can be examined within a chain of one another. Thus in Mundawah creek west of the "Spottiswoode" homestead and on the Bridgeman road, the position of the fault can be clearly seen. Also in West Brook just south of the bridge where the Westbrook road crosses, there is an excellent exposure of Carboniferous conglomerate separated by about one chain of alluvium from the Permian coal seams. The fault sometimes outcrops high up on the slopes of hills, as is the case to the south of Benvenue.

One of the most striking things about the fault is the plan of its outcrop. Thus, starting from Glendonbrook, it trends west and then north-west to the head of Mundawah Creek, when it turns and runs for about six miles in a general west by south direction to Glennie's Creek, after which it resumes its north-north-west trend to the Goorangoola road and again turns to the west by south direction. The significance of this alternation of two directions in the trend of the fault and the origin of the structure indicated by the data mentioned, are matters which are best deferred till more is known on the regions to the north.

The Bridgeman fault seems without much doubt to be an overthrust. The strongest evidence of this is to be seen in the nature of its outcrop, just described. In the field it is found that the outcrop is that of a surface dipping to the north and east respectively, and could hardly be that of a surface dipping in directions respectively opposite to these. In association with these features, the Carboniferous and Permian rocks are in most cases parallel in strike to that of the fault zone. Further, the dip directions of representatives of the two systems are in general about the same as that of the fault. Thus along Mundawah Creek and West Brook near "Spottiswoode" the Newcastle Coal Measures are dipping at angles from 50° to 70° towards the north-east, this being also the dip direction of the fault and of the Kuttung Series.

It would appear that the overthrusting which produced the fault turned over the Permian and Carboniferous strata so as to show them dipping, like the fault, in a common direction.

Relation of the Bridgeman Fault to the Webber's Creek Fault.

The Bridgeman fault, as already indicated, can be traced with ease as far east as the point where it crosses Glendon Brook. Just at this locality there is an accumulation of alluvium which covers the Palaeosoic rocks and makes it very

difficult to follow out the structural features. It is here also that the northerly trending Elderslie fault and the westerly trending Webber's Creek fault meet, so that the area is one of extreme interest from the point of view of the structure. Unfortunately one cannot make out the exact relationship of these three faults here but there are two main possibilities in connection with the matter. First, the Bridgeman fault may turn and become the Elderslie fault, thus cutting off the Webber's Creek fault which has been traced by Walkom (and confirmed by the writer) from Tamby Creek to Glendonbrook. Second, the Webber's Creek and the Bridgeman faults may be one and the same, the zone of fracture constituting them having been responsible for cutting off the Elderslie fault.

The first possibility was suggested by Browne in describing the heavy fault (called by him the Wingen fault), which separates the Permian and Carboniferous terrains in the neighbourhood of Wingen and Scone, and which as far as can be seen at the present, may be the northward continuation of the Bridgeman fault. The present writer thinks that while no dogmatic statement can be made, it is more probable that the second possibility, mentioned above, is likely to explain the facts. This conclusion is made from a consideration in the field of the outcrops of the faults.

At the critical area under discussion, it is seen to be practically impossible for the Elderslie fault, if normal in character, to turn from its northerly trend and become the Bridgeman fault, apart from the fact that this would imply that the latter fault is normal, and this is regarded as being very improbable. Further, if the Elderslie fault were an overthrust, it would still be difficult for it to turn and assume the position of the Bridgeman fault. The topographical features at the critical area are such as to lend no support to the contention made in the first possibility mentioned above.

Thus the writer is inclined to the view that the Bridgeman and Webber's Creek faults are portions of the same major fracture. Support is given to this hypothesis when one considers the relation of the Mirannie Basin to the Cranky Corner basin. This will be discussed below, and it will be seen that there are data available which are best interpreted by assuming the two faults to be parts of the same overthrust.

The Benvenue Fault.

This fault runs more or less east and west right across the Parish of Dyrring, passing a little to the south of the Benvenue homestead. Its presence can be inferred from the map by considering the outcrops of some of the lavas. Its displacement of the hornblende-andesite is very striking. Along the fault a fault-breccia has been produced in places and jointing in the rocks adjacent to the fault plane is common. The fault is normal and has an approximate throw of 500 feet. From a stratigraphical point of view the Benvenue fault is of interest in having placed the toscanite (Paterson type) against the felsite and conglomerate which are below the hornblende-andesite, there being an interval of at least 1,600 feet represented between the datum horizons mentioned. A very pronouncedly fractured and jointed zone occurs at the western end of the fault where it is against a north and south fault.

The Westbrook Fault.

The Westbrook fault trends down the valley of West Brook and is therefore more or less meridional. In one place it branches into two. It has effected a large

horizontal displacement of some of the horizons, this being seen well in the case of the andesite. Thus on the Westbrook road just past the Post Office on the slope of the hill called "The Tump", one can see the *Rhacopteris* shales which underlie the toscanite, and just a few chains to the east, these rocks are against the dacites and conglomerates of the lower portion of the Kuttung Series. The Westbrook fault comes quite close to the Benvenue fault at Westbrook and thus the area here is of the nature of a senkungsfeld. The throw of the Westbrook fault is about 600 feet. The fault can be traced down the Westbrook road, and near the Public School and to the south, it is responsible for having tipped a number of the flows up on end. These can be seen, for instance, in West Brook, showing evidence of having been fractured during the faulting.

The association of the Westbrook and Benvenue faults at the Village of Westbrook leads to the presence of an interesting structure. Thus it is clear that there has been, in this region, a certain amount of horizontal movement connected with the faulting. However, this movement was not as great as one might be led to think by inspecting the plan of the outcrops of the portions of hornblende-andesite in the faulted areas. The state of affairs is due, in part, to the fact that the andesite possesses a dip which steepens as one goes north-east; also the topography is such as to make it appear as if there had been a considerable amount of lateral movement of andesite.

The Mirannie Fault.

Of the many faults which occur in the neighbourhood of Mt. Mirannie, the Mirannie fault is the most important. This fault has a throw of only about 200-300 feet, the downthrow being to the east. It is responsible for separating the central portion of the Mirannie basin from Mt. Mirannie itself. But for the existence of this fault it is probable that the plunging syncline on Mt. Mirannie would pass under the basin at Sharp's Mtn. and thus close the Mirannie basin on the northern side over a greater extent than is now the case. The Mirannie fault together with the fault marked F_2 has helped to preserve the rocks which follow the toscanites, including the glacial beds.

Other Faults.

In addition to those described above there are some faults which may be mentioned briefly. Thus F_6 on the eastern side of the Bridgeman basin, throws to the west and possesses a throw of 200 feet. It has been responsible for arranging the andesite flows in a rather unusual way. F_4 is also a westerly dipping fault and it displaces the lavas which are so well developed near the boundary between the parishes of Broughton and Dyrring. The throw of this fault is about 150 feet.

F_3 is a small fault on the eastern side of Sharp's Mtn. and together with the Mirannie fault produces a senkungsfeld structure at Sharp's Mtn. The line of this fault is dotted on the map because it was difficult to fix its position in detail.

The long fault with semi-circular outcrop, F_1, breaks across the Mirannie basin. There is not sufficient information to allow one to place the fault definitely, but there seems to be enough evidence in the field of its existence. Thus near Myall Creek there are unmistakable signs of disturbance in the rocks, and there is clearly a cutting out of some of the Kuttung strata, which could only be due to faulting. This fault seems to throw to the north and to have let the Mirannie basin down in that direction. The easterly extension of the fault has only been hurriedly examined, but the behaviour of the hornblende-andesite near Billy Brook

is best explained by assuming a fault as shown, and it is probable that the fault, F_1, continues to the east and displaces the andesite.

Finally, there are numerous small strike and dip faults. Many of these have been mapped, but it would be impracticable to show all these faults on the geological map. There seems little doubt that the majority of them are of a normal character.

Structural Relations between the Mirannie Basin Area and the Cranky Corner Basin.

A study of the geological map shows that the Webber's Creek fault separates the area of the Mirannie basin from the Kuttung rocks of the Stanhope-Tangorin district and the Permian rocks of the Cranky Corner basin. There seems little doubt in the writer's mind that these two basins are really portions of the same large basin which existed before the occurrence of the Webber's Creek fault. During the faulting there was a certain amount of lateral movement which accounts for relative positions of the two basins at the present time. This movement was either in an easterly direction on the Cranky Corner side, or in a westerly direction on the Mirannie side. The hypothesis that the Bridgeman fault is an overthrust implies that there was an appreciable amount of lateral movement of the overthrust sheet towards the south-west and west. This movement would explain the features we find along either side of the Webber's Creek fault. If a section be drawn across the Webber's Creek fault linking up the Mirannie and Cranky Corner basins, it is seen that the conditions of structure obtaining at the present can be explained whether the Webber's Creek fault be regarded as an overthrust or not. But if the fault were to be regarded as a normal fault, then it would be impossible to reconcile the corollaries, which would result from such a view, with the data available in reference to the other faults and their associations at the critical area on the banks of Glendon Brook.

Thus the relationships between the areas dislocated by the Webber's Creek fault seem to support the view that the Bridgeman and Webber's Creek faults are the same structure. More concerning this relationship of the areas about Mirannie and Glendonbrook will be said when the writer has made examination of the northern areas of the Carboniferous belt.

Relation of the Physiography to the Structural Features.

Introductory.

As far as physiography is concerned the area described in this paper is to be considered as part of a unit of much greater extent, and a careful examination of most of the larger area would be necessary before one could arrive at a proper understanding of the evolution of the present topography.

However as the area is of considerable interest to the structural geologist, it is proposed here to make a few remarks concerning the relation of the topography to the geological structure.

General.

As has been mentioned already, it is clear that the area under consideration was converted into a peneplain after the folding and normal faulting which was produced in late Palaeozoic times. The time of the occurrence of the Bridgeman fault is unknown, but it is probable that this fault antedated the Kosciusko uplift with its concomitant faulting. Succeeding the Kosciusko uplift, erosion dissected the area to such an extent that today the aspect of the topography is that of late

maturity. The region is drained by a number of large creeks, all units in the Hunter River drainage system. In many cases the beds of the creeks for quite a considerable distance above their mouths are not far removed in height from the base-level of the whole district.

The location of the accumulation of alluvium along many of the creeks has depended on the presence, here or there, of hard bars across the courses of the creeks. An inspection of the map shows some striking illustrations of this in the case of the larger streams.

The presence of an alternation of resistant and non-resistant units in the Kuttung Series has given rise to the topography so characteristic of the Carboniferous, viz. the succession of dip-slopes and dip-escarpments. The conglomerates and tuffs which are interstratified with the hard lavas are easily eroded, because the binding material is easily attacked, both chemically and mechanically, and hence large areas are deeply dissected. On account of the thin nature of many of the lavas, they frequently fail to stand out and become easily removed along with the conglomerates.

Effects of Faulting.

The most important of the faults—the Bridgeman Fault—has been responsible for placing the resistant Carboniferous strata against the easily eroded Permian sediments, and thus the fault is extremely well marked, physiographically. It can be traced with ease on account of this fact, and at first sight might be taken to represent a fault which developed with the initiation of the present erosion cycle, rather than a revealed fault scarp, which almost certainly it is.

The other faults do not as a rule indicate their presence by the existence of scarps, but indirectly affect the topography to a considerable degree, because of the manner in which they have arranged the strata. Thus resistant and non-resistant units have been thrown into intimate association, and such an assemblage has brought about, in many cases, interesting arrangements of the creek courses, and has also been a factor in connection with the degree of erosion accomplished by the streams.

A striking arrangement of the dip-slopes and associated topographic features, due to the effect of a fault, is to be seen on the eastern side of the Bridgeman basin and thereabouts. The fault, F_6, has cut across the rocks just on the eastern rim of the basin, and where, presumably, the rocks turned over from the west and south-west dip of the basin to a northerly dip. Thus directly adjacent one finds pronounced dip-slopes whose directions are opposed to one another. The northerly dipping units may be seen in portions 148, 140, 97 and 109, Parish of Broughton.

Effects of Folding.

The folding in the rocks has been of a broad type producing basins and flatly domed anticlines. The Mirannie basin is a strong structure and the synclinal nature of Mt. Mirannie itself and the presence of an abundance of resistant toscanitic lavas here, have made it possible for Mt. Mirannie and its environs to withstand erosion and appear as fairly prominent residuals.

The Bridgeman basin, in contrast with the Mirannie basin, does not stand out as a residual. In the case of the former we have an area, the centre of which is only about 150-200 feet above sea-level. The rim of the basin consists of hornblende-andesite and the material originally overlying this andesite has been almost completely stripped by erosion, and thus, except for the alluvium, the

surface of the ground is really that of the andesite, so that the portions of the floors of the creek-valleys here, are parts of a true structural feature.

The Bridgeman basin has acted as a temporary basin of deposition in the case of Fal Brook, Goorangoola and Brandy Creeks (see map). These unite within the basin and the outlet of the main stream is across a bar of andesite. It is clear that this has acted as a temporary obstacle and has caused deposition of silt and gravel within the basin and along the course of Goorangoola Ck. These features are well seen from any of the eminences surrounding this region.

Altogether, the diversity of the rock units present, and the interesting structural features of the area, have combined to produce a topography which it is very fascinating to study. The account of this topography is out of place here, but may be contemplated when more is known of the geomorphology of the Carboniferous belt to the north and east.

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EXPLANATION OF PLATE XXVIII.

Geological map of the Mt. Mirannie and Mt. Dyrring districts.

NOTES ON *MELALEUCA PUBESCENS* SCHAUER AND *M. PREISSIANA* SCHAUER.

By E. Cheel, Curator, National Herbarium, Sydney.

[Read 25th August, 1926.]

The name *pubescens* was established in 1843 by Schauer on plants collected by Allan Cunningham during the year 1817. The description is in Latin, which may be translated as follows:—

"Shrubs with divaricate branches; leaves scattered but crowded, slightly spreading, narrow-lanceolate petiolate, flat, venation and oil-glands inconspicuous; the young growth of the branches hoary-pubescent, the older growth at length glabrous; spikes below the terminal shoots, fruits sessile, somewhat ovoid, the orifice contracted". The habitat given is "In Nova Hollandia—A. Cunningham Herb. No. 283, 1817". If we follow Cunningham's journeys during the year 1817, we find, according to Maiden (1903) that he left Port Jackson on 22nd December, 1817, and visited Twofold Bay, passed through Bass' Straits along the south coast to King George's Sound, thence to North-west Cape and a survey of the coast between this Cape and Depuch Island was made. Port Essington, among other places, was also explored, so that we may safely assume that specimens of *Melaleuca pubescens* Schauer were collected during this trip.

It is interesting to note that the species is also mentioned by Miquel (1856), who quotes Mueller as having collected it at Barker's Creek, and he gives *Melaleuca glabrescens* F.v.M. as a synonym. The name *glabrescens*, however, is not mentioned by Bentham, nor can I find any other reference to it than that of Miquel (1856). It would appear from this that Mueller's name *glabrescens* is a nomen nudum, and was intended for those specimens collected at Barker's Creek (now Mt. Barker Creek), which is about 20 miles from Adelaide. *Melaleuca parviflora* of Lindley (1839) is apparently the same species, but as Otto and Link (1822) had already applied this name to another plant in 1822, shown by various authorities to be synonymous with *M. thymifolia* of Smith (1797), we can understand why Bentham included Lindley's species, published in 1839, as a synonym under *M. Preissiana* var. *leiostachya*. Then we have still another species of *Melaleuca parviflora* Reichenbach (1837) which is synonymous with *M. decussata* R. Br. (1812). It apparently did not occur to Bentham that Schauer's name *pubescens* had priority over Schauer's *M. Preissiana*, otherwise he would, no doubt, have taken up the name *pubescens* for those plants found in Victoria, South Australia, and in some parts of Western Australia, which have decidedly hoary-pubescent branches, and the more glabrous forms could have been designated var. *leiostachya*. Schlechter (1852) evidently regarded some of the Victorian plants as distinct from the South Australian and Western Australian ones and set up the name *M. curvifolia*, but, strangely enough, Mueller (1858-59) cites *M. pubescens* Schau., as a synonym under *M. curvifolia*, which he considered to have close affinities with *M. acuminata*.

Mr. W. Gill collected specimens which are undoubtedly the *M. pubescens* of Schauer, and attached the following interesting notes concerning them: "A tea-tree I got on the west side of Spencer's Gulf, in the Range country, a few miles north of Port Lincoln, in December, 1900. These ranges are granite and slate, if I remember rightly, and this tea-tree is not a common one. The young shoots are slightly pubescent, an infrequent development in our tea-trees; this would seem to indicate *M. brachystachya*; the orifice of the fruits seem permanently lobed in the young fruit, but in the older it is not so, hence it does not appear correct to class it as *M. cylindrica* of Tate's Flora of S.A." (Gill).

Distribution.—New South Wales: Marengo (J. L. Boorman, November, 1917); Wyalong (J. L. Boorman, April, 1914, Forester Perthewaite, January, 1900, and Dr. T. Guthrie); Barmedman (Bishop J. W. Dwyer, April, 1915) and also Temora, same collector; Cowina (W. A. Burton, November, 1920); Moama (Forest Guard W. N. Watson, October, 1904).:

Victoria: Nandalay, Moondah, Wycheproof (Rev. W. W. Watts, Nos. 471, 492, October, 1917); Mallee country (Dr. Alston per Rev. W. W. Watts, Nos. 580, 608, determined as *M. parviflora* by Melbourne authorities); Point Addis (J. Staer, April, 1911).

South Australia: Murray Bridge (J. H. Maiden, January, 1907); Tintinarra Desert (R. H. Cambage, No. 253, March, 1901); Mount Gambier (W. Gill, May, 1900); Coonalpyn, 90-mile Desert (Max Koch, March, 1904); Kingscote, Kangaroo Island (J. H. Maiden, January, 1907; J. Staer, March, 1911; Dr. R. S. Rogers, September, 1908); Ravine des Casours, Kangaroo Island (Dr. R. S. Rogers); Cape du Couedic, Kangaroo Island (Dr. R. S. Rogers); Port Lincoln (J. H. Maiden, January, 1907); Moolooloo Station, between Beltana and Blinman (Mrs. Rogers, October, 1915); Quora Woolshed (Mrs. Rogers); Flinders Range (W. Gill, January, 1902); Mount Lyndhurst (Max Koch, No. 104, December, 1898); Mount Brown Forest (W. Gill, March, 1906); Glen Ferdinand, Musgrave Range: Fruits smaller than usual; the creek at the top end of the Glen was lined with this shrub (S. A. White).

Western Australia: Drummond (No. 74, 6th Collection, 1854); Maylands (Dr. F. Stoward, January, 1912); Queenswood (Max Koch, No. 2131, January, 1911); Swan Swan District (E. Pritzel, No. 156, December, 1900); Canning Plains (W. V. Fitzgerald, January, 1903); Hopetown (J. H. Maiden, September, 1909); Bumberry, York Road (Forestry Department, W.A., No. 2160); Welshpool (J. H. Maiden, September, 1909); Cape Naturaliste (J. H. Maiden, October, 1909).

The late Mr. E. Betche was always in doubt when determining specimens of this species, as will be seen by the following note attached to the series of specimens—"According to Bentham's description, this is *M. Preissiana* Schau., B. Fl. III, 145. Mueller called it *M. parviflora* Lindl. We have several distinct species under this name in the Herbarium. The matter should be cleared up. It is possible that *M. curvifolia* Schlechter and the *M. pubescens* Schau. are both, or one of them, distinct species and should be revised".

My own view is that *M. pubescens* Schauer has priority over all the other names, and that the Victorian plants are but mere forms of *M. pubescens*, and the Western Australian plants known as "Ironwood" are glabrous forms of the same species which Bentham designated var. *leiostachya*. It might be advisable to adopt both names, var. *curvifolia* and var. *leiostachya*, for the extreme forms, and regard *M. Preissiana* Schau. and *M. parviflora* Lindl. as synonyms.

We have a specimen in the Herbarium labelled *M. curvifolia* Schlechter Austral Felix, ex Herb. Melbourne. Other specimens identical with the above are also represented from the following localities:—

Sorrento, Port Phillip (C. Walter, September, 1902); Sea Lake (Rev. W. W. Watts, No. 864, February, 1918); Inglewood (J. Blackburn, February, 1907); Stuart's Creek, Lake Gregory (*F. v. Mueller* Babb. Expedition). Iter. Aust., R. Brown, 1802-5. The above I suggest might be called var. *curvifolia*.

Moore and Betche (Handbook of the Flora of N.S.W., p. 196) give *M. parviflora* Lindl. (*M. Preissiana* Schau.) as a coastal plant, i.e., "Coast district chiefly maritime". This is a mistaken identity. The plants determined as *parviflora* are *M. genistifolia* Sm. for the most part, together with a series which I believe to be *M. lanceolata* Otto (*M. parviflora* var. *latifolia*, Maiden and Betche's Census, p. 155).

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REVISION OF AUSTRALIAN LEPIDOPTERA: DREPANIDAE, LIMACODIDAE, ZYGAENIDAE.

By A. JEFFERIS TURNER, M.D., F.E.S.

[Read 29th September, 1926.]

The present instalment, after a few supplementary notes on families previously dealt with, contains a revision of three unrelated families, one of which is moderately represented in our fauna, and the other two only to a small extent.

Fam. Lymantriadae.

Unrecognized species.

Orgyia aneliopa Low., PROC. LINN. SOC. N.S.W., 1915, p. 478.

Fam. Antheliidae.

ANTHELA PYRRHOBAPHES.

Turn., *Pap. Proc. Roy. Soc. Tas.*, 1925, p. 114. Tasmania: Zeehan.

ANTHELA PHAEOZONA.

Turn., *Pap. Proc. Roy. Soc. Tas.*, 1925, p. 115. Tasmania: Bothwell.

ANTHELA EXCELLENS Wlk.

I have lately seen three ♂ examples. This species may be recognized by its brilliant orange-red wings, thorax, and abdomen, contrasting sharply with the grey-whitish head. The ♂ expands to 70 and 80 mm. The antemedian and subterminal lines and fuscous suffusion of forewing are variable; the antemedian line may be absent, or there may be two. The discal dots are absent on the upper surface, except the posterior dot on forewing, which is slightly indicated; beneath they are well developed and white-centred.

Queensland: Montville (1,500 ft.), near Nambour, Brisbane, Bunya Mts. (3,000 ft).

ANTHELA ASTATA, n. sp.

ἄστατος, unstable, variable.

♂. 50-80 mm. ♀. 84-110 mm. Head, thorax, and abdomen brown, grey-brown, ochreous-brown, or greenish-ochreous. Palpi fuscous. Antennae whitish or yellow; pectinations in ♂ 6 to 8, in ♀ 1½ to 2, brownish. Legs fuscous finely irrorated with whitish; coxae and anterior femora reddish-brown, ochreous-grey, or greenish; femora with a white apical spot. Forewings triangular, costa straight to middle, thence strongly arched in ♂, in ♀ gently and uniformly arched, apex pointed, slightly produced, often in ♀ strongly produced, termen slightly bowed, scarcely oblique; brown, grey-brown, ochreous-brown, or greenish-ochreous; often with darker suffusion or with irregular fuscous blotches; two whitish discal dots usually outlined with fuscous beneath one-third and one-half costa; usually an

irregularly dentate, outwardly curved, fuscous, transverse line from one-sixth costa to one-third dorsum, and a second from one-third costa between discal dots to mid-dorsum; a dark oblique line from two-thirds costa, usually sharply bent inwards beneath costa, to two-thirds dorsum, closely followed by a pale line; two or three strongly crenated fuscous lines beyond this, sometimes reduced to a single row of dots; cilia concolorous. Hindwings with termen rounded, tornus slightly produced; as forewings but without discal dots. Underside reddish-brown, grey-brown, or ochreous-brown with two discal dots in each wing, those in forewing always, in hindwings sometimes, whitish in centre.

Very variable. In one ♂ the forewings are pale ochreous-green, the hindwings yellow. Allied to *A. varia* but readily distinguished by the white discal dots. Occurs in tropical rain-forest or jungle.

North Queensland: Kuranda, near Cairns. Queensland: Montville (1,500 ft.), near Nambour, in February; Brisbane in December and January; Toowoomba in February and March; Bunya Mts. (3,000 ft.) in January. Twelve specimens.

Fam. Notodontidae.

Pheraspis harmonica, n. sp.

ἁρμονικος, well-blended.

♀. 55 mm. Head brownish. Palpi ochreous-whitish; posterior surface fuscous. Antennae grey; in ♀ shortly ciliated. Thorax and abdomen very pale ochreous-brown, almost whitish. Legs pale ochreous-grey. Forewings oval-triangular, costa gently arched, more so towards apex, apex rounded, termen obliquely rounded; basal area whitish-brown, limited by a dark-brown line from midcosta, at first transverse, bent inwards in disc almost to a right angle, and again bent to dorsum at one-quarter; remainder of disc ochreous-grey-whitish; a short, median, transverse, discal mark touching basal area, fuscous edged posteriorly with white; a very indistinct, double, dentate, postmedian line, grey becoming brown on dorsum; an elongate brown mark on costa before apex, containing two dark-brown longitudinal streaks; a series of blackish subterminal dots preceded by an indistinct wavy white line; cilia dark-brown mixed with whitish. Hindwings with termen rounded; ochreous-grey-whitish; a dark-fuscous tornal spot traversed by a white line; cilia concolorous.

Type in Coll. Goldfinch.

Queensland: Yeppoon in November; one specimen.

Gen. Cascera Wlk.

The generic definition should be amended as follows: Eyes with long cilia, sometimes incurved. The cilia are movable, and the presence or absence of incurving in the specimen examined therefore accidental.

Cascera amydra.

♂. Turn., Proc. Linn. Soc. N.S.W., 1903, p. 74. ♀. *Themerastis amalopa* Turn., Proc. Linn. Soc. N.S.W., 1904, p. 833.

The receipt of two ♂ and two ♀ examples taken at Cairns by Mr. F. H. Taylor enables me to make this correction. The sexes differ in the much greater distinctness of the markings in the ♀, in which the basal and median areas are sharply divided. Both sexes are variable. The anastomosis of 12 with the cell in the hindwings is not constant, but present in 6 out of my 7 examples. Though I have not

re-examined the types of *celaena* and *acrobela* there can be little doubt that they should also be referred to *Cascera*, and that my genus *Themerastis* should be dropped.

Gen. SCYTHROPHANES, nov.

σκυθροφανης, gloomy-looking.

Face hairy. Tongue strong. Palpi long, ascending; basal joint hairy; second joint moderately thickened with rough scales, appressed to face; terminal joint moderately long, porrect. Thorax not crested; shoulder-flaps triangularly elongate, projecting beyond its posterior edge. Forewings narrow, narrower posteriorly; areole well developed, 2 from two-thirds, 3 from angle, 5 from above middle of cell, 6 from base of areole, 7 separately from apex of areole, 8 and 9 stalked from areole, 10 separate, 11 free. Hindwings twice as broad as forewings, 5 from above middle of cell, 6 absent (coincident with 7), 12 closely approximated to cell to near its end.

Probably allied to *Gallaba* Wlk., with which it agrees in the structure of thorax, but very distinct. I do not know any other genus of the family in which 6 and 7 of hindwings are coincident.

SCYTHROPHANES STENOPTERA, n. sp.

στενοπτερός, narrow-winged.

♂. 44 mm. Head and thorax grey. Palpi 2; whitish, outer surface partly fuscous. Antennae grey; in ♂ bipectinate towards base, pectinations 4, apical half simple. Abdomen pale-grey. Legs whitish; anterior pair partly fuscous. Forewings narrow-oblong, beyond middle more constricted, costa sinuate, apex rounded-rectangular, termen short, obliquely rounded, dorsum sinuate; grey; some fine fuscous lines; a curved line from base to costa at one-sixth; an inwardly-oblique line from one-third costa crossing fold; a very fine crenulate line from two-thirds costa to dorsum beyond middle; indications of a dentate subterminal line; a more distinct submarginal line interrupted by veins; cilia grey. Hindwings with termen rounded; fuscous-grey becoming whitish towards base; cilia white.

Type in National Museum, Melbourne.

Victoria: Inverloch; one specimen.

Fam. Lasiocampidae.

PORELA SUBFASCIATA Wlk.

This species is known only from Tasmania. A mistake has been made by attributing specimens to Kelso, near Bathurst, New South Wales, which came from Kelso, near Launceston, Tasmania (A. Simson).

OPSIRHINA HILARÓPA.

Odonestis hilaropa Low., PROC. LINN. SOC. N.S.W., 1900, p. 403.—*Clathe pyrsocoma* Turn., *Trans. Roy. Soc. S. Aust.*, 1902, p. 185.

I unfortunately overlooked Lower's name. Though his description lacks the structural details, which are required for certainty, it agrees fairly well with my species, and I know of no other to which it will apply. His locality, Cape York, North Queensland, also agrees with this identification.

Fam. Drepanidae.

Tongue usually present. Palpi usually short or minute. Forewings with 1 absent, 5 from near lower angle of cell, areole present or absent, 11 from near end

of cell, or from areole, or stalked with 10. Hindwings with second anal short, running to dorsum, or absent, 1 absent, 5 from near lower angle of cell, 6 and 7 remote at origin, 7 from costal margin of cell, approximated to 12 after origin, or rarely anastomosing with 12. Frenulum and retinaculum present, or absent, being then replaced by a basal costal expansion of hindwings.

Although a family of only moderate size the Drepanidae show a wide range of structure. They are notwithstanding a very natural group and easily recognized. The approximation of 7 to 12 in the hindwings is a characteristic found also in the Cymatophoridae as well as in the Pyraloidea. The anastomosis of these veins, so characteristic of most Pyraloidea is found elsewhere only in a few Drepanidae. I see no reason to doubt that it has been independently developed in both cases. That the Drepanidae are not nearly allied to the Pyraloidea is sufficiently established by the presence of an areole projecting distally from the cell in most genera. Those in which the areole has been lost are derived forms, and the loss has been either by coalescence or (rarely) by loss of the interradial anastomosis, never by obsolescence of the chorda as in the Pyraloidea. We must indeed refer the Drepanidae to the superfamily Noctuoidea, where, however, they have no close allies, and are aberrant by the relationship of the veins 7 and 12 of the hindwings.

In Australia the family is represented by only three species belonging to three genera, which constitute an aberrant section of the family, for in them proboscis, frenulum, and retinaculum are absent, and the areole is extremely long and narrow, or lost by failure of the interradial anastomosis. *Oreta* is an Oriental genus represented by ten species in India; the other two genera, though recognized at present in Australia only, are probably Papuan.

Key to Genera.

1. Hindwings with 7 anastomosing with 12 2
   Hindwings with 7 after its origin approximated to 12, not anastomosing ...... *Oreta*
2. Forewings with 8 absent, 11 anastomosing with 10 .... *Amphitorna*
   Forewings with 8 present, 11 not anastomosing .... *Astatochroa*

Gen. 1. Amphitorna.

Turn., *Ann. Qld. Mus.*, x, 1911, p. 96.

Tongue absent. Palpi short, porrect; second joint hairy; terminal joint smooth. Antennae laminate; the laminae over 1, in ♂ fused together, in ♀ separate. Tibiae with terminal spurs fairly well developed, the outer spurs shorter; posterior tibiae without middle spurs. Forewings with 8 absent, 7 and 10 arising separately from cell, 9 long-stalked with 10 and anastomosing shortly with 7 to form the areole, which is very narrow and very long, reaching to near apex of wing, 11 arising from shortly before end of cell, and anastomosing with 10 for a considerable distance. Hindwings with second anal absent, 7 arising from upper margin of cell at about two-thirds, and anastomosing with 12 for some distance. Frenulum and retinaculum absent; hindwings with strong basal costal expansion.

Type, *A. lechriodes*. I formerly erroneously identified this species as *fuscimargo* Warr., of which I had not then seen an example.

1. Amphitorna lechriodes, n. sp.

λεχριωδης, oblique.

♂. 32 mm. Head and thorax reddish-ochreous; face red; upper and lower margins pale-ochreous. Palpi pale-ochreous. Antennae reddish. Abdomen grey-

whitish, base of dorsum reddish. Legs pale-ochreous. Forewings triangular, costa strongly arched, apex acute, strongly produced and falcate, termen sinuate, scarcely oblique; reddish-ochreous with some darker irroration; an outwardly-oblique dark-reddish line from two-thirds costa to vein 6, there angled and inwardly oblique to three-fifths dorsum; cilia dark-reddish. Hindwings with termen gently sinuate; as forewings, but transverse line from mid-dorsum straight, not reaching costa.

♀. 38 mm. Like ♂ but pale ochreous-grey without reddish tinge. Wings without oblique line.

North Queensland: Kuranda, near Cairns, in December and April; two specimens received from Mr. F. P. Dodd.

Gen. 2. Astatochroa nov.

ἀστατοχροος, unstable in colour.

Tongue absent. Labial palpi very short; hairy towards base. Antennae bipectinate. Forewings with a long areole, or 8 disconnected leaving areole open, 7, 8, 9, 10 stalked, 9 and 10 arising out of 8 near base, or the stalk of 9 and 10 connate with 7 and 8, 6 and 11 connate with preceding veins from upper angle of cell, or 11 approximated only. Hindwings with 4 and 5 approximated from angle of cell, 7 arising from shortly before upper angle and anastomosing with 12 for some distance. Frenulum and retinaculum absent; hindwings with strong basal costal expansion.

According to Warren both 6 and 11 are sometimes stalked with 7, 8, 9, 10.

2. Astatochroa fuscimargo.

Oreta fuscimargo Warr., *Novitates Zoologicae*, 1896, p. 338.—*Oreta pusilla* Warr., *ibid.*, 1900, p. 99.—*Oreta roseola* Warr., *ibid.*, 1900, p. 99.—*Artaxa usta* Luc., *Proc. Roy. Soc. Qld.*, 1901, p. 76.

♂, ♀. 22-30 mm. Head and thorax yellow; face reddish-brown. Legs pale-yellow; anterior coxae and femora reddish anteriorly. Forewings triangular, costa moderately arched, apex round-pointed, slightly produced, termen straight; yellow; a whitish discal dot before middle surrounded by reddish suffusion; a fine reddish line from mid-dorsum to discal dot; a similar line from costa before apex, slightly curved outwards beneath costa, thence straight to three-fourths dorsum; variable reddish or fuscous spots or suffusion preceding termen; cilia yellow. Hindwings with termen gently rounded; colour and lines as forewings.

I describe this as the typical form, but the species is very variable in colour and markings. The transverse lines may be absent from both wings. An example from Toowoomba differs as follows: Face reddish. Thorax reddish-brown, anterior edge whitish. Wings reddish-brown. Forewings with no suffusion around discal dot; a fine dark line, edged posteriorly with ochreous, from near apex to three-fourths dorsum; some fuscous strigulae before termen. Hindwings with a dark line from two-thirds dorsum extending three-quarters across disc. Warren himself suggested (*Novitates Zool.*, 1900, p. 98) that the three forms he had described might be one species. I have examined Lucas's type, which is in the South Australian Museum.

North Queensland: Cairns. Queensland: Yeppoon (E. J. Dumigan), Toowoomba (W. B. Barnard), Southport (H. Hacker). New South Wales: Port Macquarie (G. M. Goldfinch).

Gen. 3. Oreta.

Wlk., *Cat. Brit. Mus.*, v, p. 1166; Hmps., *Moths India*, i, p. 347.

Tongue absent. Palpi very short, porrect, hairy. Antennae bipectinate in both sexes, the pectinations sometimes fused together in ♂. Terminal tibial spurs very short or absent; posterior tibiae without middle spurs. Femora hairy. Forewings with 2 from before middle of cell, 3 from about midway between 2 and angle, 3 and 4 approximated from angle, 6 from upper angle, 7 and 8 long-stalked to near apex, 9, 10, 11 stalked, 9 anastomosing with 8, or with 7, 8 shortly before bifurcation, forming a very narrow, very long areole, which reaches to near apex. Hindwings with second anal absent, 7 from costal margin of cell at about two-thirds, approximated to 12 after its origin. Frenulum and retinaculum absent; hindwings with strong basal costal expansion.

There is some variation in antennal and tibial structure, but there seems to be no need to divide the genus as here defined.

Type, *O. extensa* Wlk., from India.

3. Oreta jaspidea.

Oobanilla jaspidea Warr., *Novit. Zoolog.*, 1896, p. 335.—*C. erminea* Warr., *ibid.*, 1899, p. 1.—*Oreta miltodes* Low., *Trans. Roy. Soc. S. Aust.*, 1903, p. 29.—*O. hypocalla* Low., *ibid.*, 1905, p. 179.

♂. 37-40 mm. ♀. 50 mm. Head ochreous; forehead and face bright red becoming ochreous towards basal margin. Antennae ochreous-grey. Thorax ochreous-grey, sometimes reddish-tinged. Abdomen, dorsum as thorax; beneath reddish. Legs ochreous, sometimes reddish-tinged; anterior pair mostly red. Forewings triangular, costa straight to three-fourths, thence strongly arched, apex strongly produced and obtusely falcate, termen nearly straight or slightly sinuate; pale-ochreous or reddish with numerous darker transverse striae; usually a paler basal blotch, sometimes sharply defined with its posterior edge from one-third costa obliquely outwards, sharply angled inwards beneath costa, and rounded to near base of dorsum; sometimes a more darkly shaded median band, which may contain one or two minute whitish discal dots; sometimes a pale costal patch, rather narrow, from two-thirds costa to apex; apex sometimes with some fuscous and whitish irroration; sometimes an oblique fuscous line, which may be edged posteriorly with whitish, from apex to two-thirds dorsum; cilia dark-reddish. Hindwings with termen rounded, tornus prominent and rounded-rectangular; colour, striae, and cilia as forewings; a minute median whitish discal dot, and sometimes a few similar dots in disc; striae near apex sometimes fuscous. Underside similar, but more reddish or orange; oblique line on forewings distinct.

A variable species, both in coloration, details of marking, and especially in development of oblique line on forewings, but in my examples this is always present on underside.

North Queensland: Cooktown (Warren); Kuranda, near Cairns; Townsville in December and January (F. P. Dodd); Mackay (Lower). Also from New Guinea.

Index to Drepanidae.

Genera.

SPECIES.
(Synonyms in italics.)

Erminea, 3; fuscimargo, 2; *hypocalla*, 3; jaspidea, 3; lechriodes, 1; *miltodes*, 3; *pusilla*, 2; *roseola*, 2; *usta*, 2.

Fam. Limacodidae.

Tongue absent. Forewings with 1 (the second cubital vein) well developed throughout, 8 and 9 always stalked, areole always absent, median vein nearly always present in cell. Hindwing with 12 connected with cell either by vein 11 or by an anastomosis towards base, 1 present, median vein nearly always present in cell.

The palpi are usually short or moderate, rarely long. The antennae are bipectinate (rarely unipectinate) in the male, sometimes to apex, but usually becoming simple (sometimes abruptly) long before apex. The thorax and abdomen are stout, and the former is very rarely crested. The legs are densely hairy, the spurs being often short and concealed, with the middle spurs absent; rarely all spurs are absent.* The median vein is sometimes forked in the forewing but often single; in the hindwing single or very rarely stalked. Veins 2, 3, 4, 5 are always present and well separated at origin, at least in Australian genera.

The larvae are highly specialized, being without abdominal prolegs, either smooth-skinned or sparsely spined, and sometimes with several groups of protrusible stinging hairs. The pupae are closely enclosed in smooth oval cocoons from which the imago emerges through the dehiscence of a circular lid at one extremity. Usually these are freely exposed, or found under loose bark, but in some species, as has been shown by Mr. W. H. Matthews, of Perth, in the case of *Anaxidea lactea*, are formed underground.

The Limacodidae are a family of moderate size characteristic of tropical regions and rare in the temperate zones, but of world-wide distribution in continental regions. They form a compact group of early origin but in many ways specialized. Primitive characters are the retention of the second cubital and median veins; specialized characters, the absence of the tongue and of the areole in the forewings. With the Psychidae they form the superfamily Psychcidea. The absence of the areole is due to coalescence, which is already present in the pupal neuration, for Dr. R. J. Tillyard informs me that in the pupal tracheation of *Doratifera* the third and fourth radial tracheae (corresponding to veins 9 and 8) in the forewings have coalesced at their bases. Formerly I included the Zygaenidae in the Psychoidea, but, for reasons which will be given presently, am now satisfied that this was an error.

Owing to the compact relationships of the various genera the internal classification of the family presents some difficulty. Primarily it may be divided into genera in which 11 of the hindwings unites 12 with the cell, and those in which 11 has disappeared and been replaced by an anastomosis. In *Doratifera* and *Lamprolepida* this anastomosis is prolonged to or beyond the middle of the cell. The origin of vein 10 is of no value for generic determination, as it varies in many species; that of 7 is more constant, and may be used with caution. The presence or absence of middle tibial spurs, or rarely the absence of all spurs, furnishes reliable characters, though, as already noted, they are sometimes difficult of observation.

* On account of the hairiness, descaling may be necessary to demonstrate this.

Key to Genera.

1.	Hindwings with 11 absent, 12 anastomosing with cell	2
	Hindwings with 11 present, 12 not anastomosing	12
2.	Hindwings with 12 anastomosing to or beyond middle	3
	Hindwings with 12 anastomosing near base or before middle	4
3.	Tibiae without spurs	*Lamprolepida*
	Tibiae with terminal spurs	*Doratifera*
4.	Hindwings with 6 and 7 connate or stalked	5
	Hindwings with 6 and 7 widely separate at origin	*Anapaea*
5.	Forewings with 10 absent	*Apodecta*
	Forewings with 10 present	6
6.	Forewings with 7 connate or stalked with 8, 9	7
	Forewings with 7 separate	11
7.	Palpi porrect	8
	Palpi ascending	10
8.	Posterior tibiae without middle spurs	*Parasa*
	Posterior tibiae with middle spurs	9
9.	Antennae of ♂ unipectinate	*Eonomoctena*
	Antennae of ♂ bipectinate	*Thosea*
10.	Palpi short, closely appressed to and not exceeding middle of frons	*Chalcoscelis*
	Palpi long (2 or more), obliquely ascending	*Anepopsia*
11.	Posterior tibiae without middle spurs	*Hypobleohra*
	Posterior tibiae with middle spurs	*Birthama*
12.	Posterior tibiae without middle spurs	13
	Posterior tibiae with middle spurs	14
13.	Palpi very long, dilated by hairs at apex	*Scopelodes*
	Palpi short or moderate, not dilated at apex	*Anaxidea*
14.	Palpi very long (4 to 6)	15
	Palpi short or moderate	16
15.	Size large; hindwings with 11 from towards base of cell	*Hedraea*
	Size very small; hindwings with 11 from middle of cell	*Elassoptila*
16.	Thorax crested	*Hypselolopha*
	Thorax not crested	*Susica*

Gen. 1. Lamprolepida, nov.

λαμπρολεπιδος, with brilliant scales.

Lamprolepis Feld., *Reise Novara* (*nomen nudum*).

Palpi moderate, porrect, thickened with appressed hairs; terminal joint short, concealed. Antennae of ♂ with a double row of long pectinations towards base, towards apex simple. Legs densely hairy; tibiae without spurs. Forewings with a single median vein in cell, 7, 8, 9 stalked, 10 connate or short-stalked. Hindwings with a single median vein in cell, costal edge of cell about four-fifths, 6 and 7 stalked, 12 anastomosing with cell from near base to about four-fifths.

Type *L. chrysochroa* Feld. A development of *Doratifera* differing in the loss of the tibial spurs. This I have verified by descaling. It differs also in the longer anastomosis of 12 of hindwings with cell.

1. Lamprolepida chrysochroa.

Lamprolepis chrysochroa Feld., *Reise Novara*, Pl. 82, f. 18.—*Doratifera euchrysa* Low., *Trans. Roy. Soc. S. Aust.*, 1896, p. 152.

♂. 28-30 mm. ♀. 34-40 mm. Head reddish-brown. Palpi in ♂ 1½, in ♀ 2½; dark-brown, upper surface reddish-brown. Antennae reddish-brown; in ♂ with long pectinations at base ceasing rather abruptly in middle. Thorax reddish-brown, laterally and posteriorly dark-brown. Abdomen and legs dark-brown. Forewings semi-oval, costa straight to near apex, apex round-pointed, termen obliquely rounded; dark golden with metallic lustre; dorsal edge dark brown;

an oblique dark brown line from costa before apex to above one-third dorsum; a narrow dark brown terminal fascia with darker anterior edge, broadest at apex, narrowing to a point above tornus; cilia dark brown. Hindwings with termen nearly straight in ♂, rounded in ♀; ochreous-brown; cilia ochreous-brown.

North Queensland: Thursday Island, Cape York, Cairns, Herberton, Palm Islands, Townsville, Mackay.

Gen. 2. DORATIFERA.

Westw., Duncan, *Nat. Libr. Exot. Moths*, 1841, p. 181.

Palpi porrect, short or moderately long, hairy. Antennae of ♂ bipectinate towards base, pectinations long, apical half or more simple, or rarely very shortly pectinated. Tibial spurs short, concealed; posterior tibiae without middle spurs. Forewings with a single median vein in cell, 7, 8, 9 stalked, 10 approximated, connate, or stalked with them from upper angle of cell. Hindwings with a single median vein in cell, upper margin of cell three-fourths to five-sixths, 6 and 7 stalked, 11 absent, 12 anastomosing with cell as far as middle.

The stalking of vein 10 of the forewings is a variable character in several species.

Type *D. vulnerans* Lewin.

Key to Species.

1. Forewings grey-whitish 2
   Forewings not grey-whitish 4
2. Forewings wholly grey-whitish 3
   Forewings with reddish-brown subterminal fascia .... *oohroptila*
3. Antennal pectinations of ♂ ceasing at two-fifths; hindwings white .... *olorina*
   Antennal pectinations of ♂ extending to three-fourths; hindwings grey .... *pinguis*
4. Thorax and abdomen partly red or orange 5
   Thorax and abdomen not partly red or orange 6
5. Forewings of ♂ partly hyaline, or with pale-grey terminal band .... *oxlei*
   Forewings not hyaline and without terminal band .... *corallina*
6. Forewings with narrow grey terminal band .... *vulnerans*
   Forewings without grey terminal band 7
7. Forewings with dark-fuscous dots, but without whitish streak from apex 8
   Forewings without spots, but with whitish streak from apex .... *unicolor*
8. Antennal pectinations of ♂ ceasing before middle; in ♀ forewing spots not outlined with yellowish .... *quadriguttata*
   Antennal pectinations of ♂ extending to two-thirds; in ♀ forewing spots outlined with yellowish .... *casta*

2. DORATIFERA OXLEI.

Bombyx oxlei Newm., *Zoologist*, 1855, App. p. 211.—*Panisa circumdata* Wlk., *Cat. Brit. Mus.*, iv, p. 969.—*Anapaea confusa* Wlk., *ibid.*, v, p. 1117.

♂. 23-26 mm. Head reddish. Palpi 1; brownish. Antennae reddish-brown; pectinations long at base, becoming very short rather abruptly about middle, but continued almost to apex. Thorax fuscous-brown; anterior edge and two longitudinal lines red. Abdomen fuscous-brown; dorsum of basal segment red; tuft whitish. Legs fuscous-brown; anterior tibiae and all tarsi annulated with whitish. Forewings semi-oval, costa sinuate, apex round-pointed, termen obliquely rounded; fuscous-brown, semi-hyaline except on margins and veins; cilia fuscous-brown. Hindwings with termen slightly rounded; as forewings.

♀. 42-50 mm. Head reddish-brown. Palpi 1 to 1½; reddish-brown. Antennae reddish-brown. Thorax reddish-brown; lateral margins dark-brown. Abdomen reddish-brown. Legs as in ♂. Forewings with costa straight to near apex; dark

brown with paler transverse strigulae; a grey-whitish or grey terminal fascia, moderately broad at apex, narrowing gradually to tornus; cilia grey-whitish. Hindwings with termen rounded; grey, brownish towards base, sometimes wholly brownish; cilia grey-whitish.

There is considerable sexual disparity both in size and colour.

Queensland: Mt. Tambourine. New South Wales: Glen Innes, Sydney, Jervis Bay. Victoria: Melbourne, Wandin, Moe, Gisborne, Euroa. Western Australia: Perth. Tasmania: Hobart.

3. Doratifera vulnerans.

Bombyx vulnerans Lewin, *Prodr. Ent.*, 1805, p. 5, Pl. 4.

♂. 32-34 mm. ♀. 36-43 mm. Head brownish with a small tuft of white scales in front of antennae. Palpi in ♂ 1, in ♀ 2; brownish, apex whitish. Antennae brownish; in ♂ with long pectinations at base, ceasing rather abruptly at about one-third. Thorax and abdomen brownish. Legs brownish; anterior tibiae and tarsi with white dots on dorsal surface. Forewings semi-oval, costa straight to near apex, in ♂ slightly sinuate, apex rounded, termen obliquely rounded; dark reddish-brown with transverse corrugations giving the appearance of lustrous strigulae; a whitish transverse mark on end of cell; veins slenderly whitish; a narrow, whitish-grey, terminal fascia, broadest on costa, gradually narrowing to tornus; a brownish terminal line; cilia whitish with a median grey line.

Northern Territory: Darwin. North Queensland: Cape York, Cairns, Herberton, Townsville. Queensland: Rockhampton, Maryborough, Brisbane, Toowoomba. New South Wales: Lismore, Tabulam, Newcastle, Sydney, Jervis Bay, Mittagong. Victoria: Melbourne. South Australia: Adelaide. Western Australia: Perth.

4. Doratifera ochroptila, n. sp.

ὠχροπτιλος, pale-winged.

♀. 36 mm. Head and palpi ochreous-whitish. Antennae ochreous-whitish; in ♀ simple. Thorax and abdomen whitish-ochreous. Legs ochreous-whitish. Forewings rather elongate, costa straight, apex rounded, termen obliquely rounded; grey-whitish with some brownish suffusion and lustrous striations; a reddish-brown subterminal fascia intersected by grey-whitish veins and not reaching margins, narrow but wider between veins 5 and 6; a narrow whitish-grey terminal fascia widest in middle; cilia whitish-grey. Hindwings with termen rounded; whitish; cilia whitish.

Near *D. vulnerans*, but with whitish hindwings, and much paler forewings.

N.W. Australia: Sherlock River; one specimen in the British Museum. A second ♀ example from Bernier Island, Sharks' Bay, is in Coll. Lyell.

5. Doratifera olorina, n. sp.

olorinus, swan-like.

♂. 26-30 mm. ♀. 38-42 mm. Head whitish. Palpi under 1, with loosely appressed hairs; whitish. Antennae grey-whitish; in ♂ with long pectinations towards base, ceasing abruptly at two-fifths, thence serrate or simple; in ♀ simple. Thorax and abdomen whitish, often tinged with grey on dorsum; underside of abdomen in ♀ blackish. Legs whitish-grey. Forewings semi-oval, costa in ♂ sinuate, in ♀ straight to near apex, apex rounded, termen obliquely rounded, whitish-grey with lustrous transverse corrugations; veins outlined with whitish; a broad grey line, interrupted by veins, from beyond cell at two-thirds to mid-

dorsum; a similar subterminal line, suffused anteriorly, defined posteriorly by a broad whitish terminal line; terminal edge grey; cilia whitish. Hindwings with termen rounded; whitish; sometimes a grey terminal line; cilia whitish.

Queensland: Rockhampton, Brisbane, Toowoomba.

6. DORATIFERA PINGUIS.

Pelora pinguis Wlk., *Cat. Brit. Mus.*, v, p. 1119.

♂. 30 mm. ♀. 34 mm. Closely similar to the preceding, but of a somewhat deeper grey. Antennae of ♂ bipectinate, pectinations moderately long at base, shortening very gradually, and extending to about three-fourths. Hindwings grey.

Victoria: Sale. Tasmania: Launceston, Ulverstone, Hobart, Triabunna.

7. DORATIFERA QUADRIGUTTATA.

Anapaea quadriguttatá Wlk., *Cat. Brit. Mus.*, v, 1855, p. 1117.—*Doratifera lewini* Scott, *Aust. Lep.*, 1864, p. 17, Pl. 6.

♂. 24-34 mm. ♀. 34-42 mm. Head reddish-brown. Palpi in ♂ 1, in ♀ 1¼; reddish-brown. Antennae reddish-brown; in ♂ with moderate pectinations at base ceasing rather abruptly at two-fifths. Thorax reddish-brown. Abdomen in ♂ dark-brown, in ♀ brownish-ochreous. Legs brown. Forewings semi-oval, costa straight to near apex, in ♂ slightly sinuate, apex round-pointed, termen slightly rounded, oblique; reddish-brown, surface corrugated to form paler lustrous transverse strigulations; usually an oblique series of dark-fuscous dots running in a line from above mid-dorsum to before apex, two or three above and two or three beneath middle, often only the two last are developed, and occasionally all are absent; cilia reddish-brown. Hindwings with termen rounded; brownish-ochreous, paler towards base; cilia brownish-ochreous.

Northern Territory: Mary River, Newcastle Waters. North Queensland: Cairns, Townsville. Queensland: Eidsvold, Brisbane, Toowoomba. New South Wales: Glen Innes, Newcastle, Sydney, Bathurst, Nyngan. Victoria: Sale, Wandin, Wangaratta. South Australia: Adelaide. Western Australia: Perth. Northwest Australia: Hammersley Range.

8. DORATIFERA CASTA.

Scott, *Aust. Lepid.*, p. 18, Pl. vi.

From Scott's excellent plates it is evident that the larva of this species is very different from that of *quadriguttata*, but the moths are hardly distinguishable. This has been confirmed by Mr. J. A. Kershaw, of Melbourne, and Mr. H. Hacker, of Brisbane. The larva of *casta* is velvety-black with numerous creamy-white spots and spines; that of *quadriguttata* is green with lozenge-shaped red markings, its spines are also green, except the anterior and posterior pairs, which are red.

Unless the larvae were known, no one would have suspected the existence of two species. So far as my material enables me to judge there is a slight difference in the structure of the antennae in the ♂; in *quadriguttata* the inner row of pectinations does not extend beyond the middle; in *casta* they extend to about two-thirds. I am unable to point out any other constant difference. In *quadriguttata* the hindwings are usually, but not always paler towards base; this is not so in *casta*. Both species vary in the number of dark spots on the forewings, but in *casta* these are uniformly outlined with yellowish in both sexes, in *quadriguttata* these yellowish rings appear to be developed only in the male, not at all, or very rarely in the female.

Queensland: Duaringa, Caloundra, Brisbane, Stradbroke I. New South Wales: Newcastle, Bathurst. Victoria: Stawell.

9. DORATIFERA CORALLINA.

Parasa corallina Turn., *Trans. Roy. Soc. S. Aust.*, 1902, p. 192.

A ♂ in Coll. Lyell shows the following differences from the ♀ type:—25 mm. Antennae bipectinate, pectinations moderately long towards base, ceasing rather abruptly about middle. Head and thorax dark reddish-purple, anterior edge of thorax bright-red. Abdomen pale-reddish-ochreous with a bright-red basal dorsal spot. Forewings with 7, 8, 9, 10 stalked.

Northern Territory: Darwin. North Queensland: Townsville.

10. DORATIFERA UNICOLOR.

Doratifera unicolora Swin., *Ann. Mag. Nat. Hist.* (7) ix, 1902, p. 418.—*Doratifera stenora* Turn., *Trans. Roy. Soc. S. Aust.*, 1902, p. 189.

Queensland: Rockhampton. Northwest Australia: Roeburne, Broome.

Gen. 3. APODECTA.

Turn., *Trans. Roy. Soc. S. Aust.*, 1902, p. 189.

Palpi moderately long, porrect; second joint thickened with closely appressed scales. Antennae of ♂ bipectinate towards base, pectinations long, apical two-fifths simple. Tibial spurs rather long, not concealed; posterior tibiae with middle spurs well developed. Forewings with a single median vein in cell, 7, 8, 9, usually stalked, but 7 sometimes connate or separate, 10 absent. Hindwings with a single median vein in cell, costal edge of cell three-fourths, 6 and 7 stalked, 11 absent, 12 anastomosing with cell from near base to about one-third.

Type, *A. monodisca* Turn.

11. APODECTA MONODISCA.

Turn., *Trans. Roy. Soc. S. Aust.*, 1902, p. 189.—*Anisobathra actinias* Low., *ibid.*, p. 221.

Northern Territory: Melville I. North Queensland: Thursday I., Cairns, Townsville, Mackay. Queensland: Westwood, Stradbroke I.

Gen. 4. PARASA.

Moore, *Lep. East India Co.*, 1859, p. 413.

Palpi moderate, porrect, clothed with appressed hairs. Antennae of ♂ bipectinate towards base, pectinations long, apical half or one-third simple, or with short pectinations to apex; of ♀ simple, or shortly bipectinate to three-fourths. Thorax sometimes with a small posterior crest. Tibial spurs short, not concealed; posterior tibiae without middle spurs. Forewings with single or forked median vein in cell, 7 connate or stalked with 8, 9, 10 separate, connate, or stalked. Hindwings with median vein in cell shortly forked, costal edge of cell about four-fifths, 6 and 7 stalked, 11 absent, 12 anastomosing with cell before middle, sometimes a series of branching pseudoneuria from 12 towards costa. Type, *P. lepida* Cram. from India.

1.	Forewings with whitish oblique median line more or less developed	2
	Forewings without whitish median line	5
2.	Forewings with median line dentate (in ♀ broadly suffused)	*atmodes*
	Forewings with median line narrow, not dentate	3
3.	Forewings whitish or grey, purplish-tinged	*ontima*
	Forewings reddish-brown or brownish	4

4. Forewings with a dark line from costa to termen .... *callidesma*
Forewings without line from costa to termen .... *bombycoides*
5. Forewings marked with numerous dark lines 6
Forewings not marked with numerous dark lines 7
6. Forewings with a sinuate sub-basal line to one-fourth dorsum .... *paroa*
Forewings with a subdorsal line from base to middle .... *neurocausta*
7. Forewings with a short oblique streak from dorsum before middle .... *alphaea*
Forewings without oblique dorsal streak 8
8. Hindwings reddish-brown .... *pyrrhothrix*
Hindwings pale-grey .... *aorata*

12. PARASA ATMODES.

♂, Turn., *Trans. Roy. Soc. S. Aust.*, 1902, p. 192.—♀ *P. loxoleuca* Turn., *Trans. Roy. Soc. S. Aust.*, 1904, p. 242.

In the ♂ the median white line is very slender and finely dentate; in the ♀ it forms a broad fascia dentate on posterior edge.

North Queensland: Cape York, Laura, Cairns, Townsville. Queensland: Brisbane, Dalby.

13. PARASA BOMBYCOIDES.

Lethocephala bombycoides Feld., *Reise Novara*, Pl. 83, f. 14.—*Thosea luxa* Swin., *Ann. Mag. Nat. Hist.* (7), ix, 1902, p. 165.—*T. erecta*, Swin., *ibid.*, p. 418.—*Doratiphora amphibrota* Low., *Trans. Roy. Soc. S. Aust.*, 1902, p. 216.—*D. sphenosema* Low., *ibid.*, p. 217.

♂. 19-24 mm. ♀. 26-32 mm. Head, thorax, and abdomen reddish-brown, dark brown, or whitish-brown. Palpi under 1; reddish-brown or whitish-brown. Antennae brownish; in ♂ with long basal pectinations, which shorten rather abruptly at two-thirds, but are continued to apex; in ♀ the pectinations are much shorter, and diminish gradually to apex. Legs brownish. Forewings with costa straight, apex rounded, termen rounded, slightly oblique; 7 usually connate, sometimes stalked, 10 separate; reddish-brown, ochreous-brown, or whitish-brown; a straight whitish streak from one-third dorsum to costa beyond middle, often conspicuous sometimes partly obsolete, or even absent; in ♂ usually a suffused darker circular spot in disc at three-fourths, but this is sometimes obsolete; sometimes a greyish suffusion along termen; cilia concolorous. Hindwings with termen strongly rounded; brown or brown-whitish.

Very variable in colour and development of markings, but not difficult of recognition, especially if attention be paid to antennal structure.

Northern Territory: Darwin, Mary River, Tennant's Creek. North Queensland: Thursday Island, Claudie River, Cooktown. Northwest Australia: Roeburne, Sherlock River, Hammersley Range.

14. PARASA CALLIDESMA.

Lethocephala ? callidesma Low., *Trans. Roy. Soc. S. Aust.*, 1896, p. 153.

♂. 26-36 mm. Head and palpi dark-brown. Thorax with a small posterior crest; dark-brown, anterior edge and centre reddish-brown, crest whitish edged with blackish. Antennae ochreous-brown; in ♂ with long pectinations in basal half, becoming short beyond middle, but continued to apex. Abdomen and legs brown or grey-brown. Forewings triangular, costa straight to near apex, apex rounded, termen rounded, slightly oblique; 7 connate or stalked, 10 separate; dark-brown; a darker basal area sharply defined by an oblique whitish line from one-third dorsum towards, but not reaching, four-fifths costa; a fuscous line from four-fifths costa to termen below middle, slightly inwardly curved; cilia brown,

apical half sometimes fuscous, extreme apices whitish. Hindwings with termen strongly rounded; brownish; cilia as forewings.

Northern Territory: Adelaide River (J. J. Walker), in British Museum. North Queensland: Cairns, Mackay (Lower). Queensland: Toowoomba, in March; two specimens received from Mr. W. B. Barnard.

15. Parasa entima, n. sp.

ἔντιμος, esteemed.

♂. 34 mm. ♀. 42-44 mm. Head and palpi reddish-brown; sides of face fuscous-brown. Antennae fuscous; pectinations in ♂ long in basal half, ochreous-tinged, thence gradually diminishing, but continued to apex. Thorax with a small posterior crest; in ♂ grey, shoulder-flaps grey-whitish, crest whitish edged with black; in ♀ grey, an anterior spot and edges of crest reddish-brown. Abdomen fuscous in ♂, grey in ♀, with a median dorsal series of reddish-brown spots. Legs grey; posterior pair whitish. Forewings triangular, costa straight to near apex, apex round-pointed, termen only slightly rounded, slightly oblique; 7 connate, 10 separate; grey, sometimes faintly tinged with purple, in ♂ broadly suffused with whitish over costal area; a straight, oblique, fine, fuscous line from one-third dorsum towards, but sometimes not reaching costa beyond middle, edged posteriorly by a whitish line; slight lustrous corrugations from dorsum; cilia grey, apices whitish. Hindwings with termen rounded; purple-grey; cilia as forewings.

Queensland: Southport in August and September, Toowoomba in March; four specimens received from Mr. W. B. Barnard, who has the type. New South Wales: Lismore, Tuncurry, Newcastle (Scott collection, in Australian Museum).

16. Parasa paroa.

Turn., *Trans. Roy. Soc. S. Aust.*, 1902, p. 191.

♂. 24-25 mm. ♀. 30-34 mm. Head ochreous-brown. Palpi fuscous or brown. Antennae brownish; in ♂ with long pectinations (5) ceasing abruptly at three-fifths, apical two-fifths simple. Thorax dark-brown, sometimes with some whitish hairs. Abdomen ochreous-brown. Legs brown or fuscous, sometimes with some whitish hairs. Forewings broadly triangular, costa straight to three-fourths, thence arched, apex rounded, termen rounded, slightly oblique, 10 usually stalked, sometimes connate; dark reddish-brown, sometimes with some whitish suffusion; markings dark fuscous; a sinuate line from above middle near base to one-fourth dorsum; a straight transverse line from lower edge of cell at one-third to fold; an outwardly curved line from midcosta half-way across disc; closely preceding this an inwardly curved line from beneath costa obliquely outwards to join postmedian line; postmedian from three-fourths costa, finely dentate on veins, at first transverse, then bent inwards to dorsum at three-fourths; veins in posterior part of disc more or less defined by dark scales; a fine terminal line; cilia brown, bases paler, apices rarely whitish. Hindwings with termen rounded; pale-brown; cilia brown.

Northern Territory: Darwin in November, December, and February. North Queensland: Cairns. Queensland: Duaringa, Brisbane.

17. Parasa neurocausta, n. sp.

νευροκαυστος, with scorched veins.

♂. 21-26 mm. ♀. 30 mm. Head and thorax ochreous-brown or reddish-brown. Palpi under 1; brown. Antennae pale-brown; pectinations in ♂ 6, apical two-fifths

simple, the long pectinations ceasing abruptly. Abdomen reddish-brown. Legs brown. Forewings with costa straight to three-fourths, thence arched, apex rounded, termen nearly straight, slightly oblique; 7, 8, 9, 10 stalked; ochreous-grey, in ♀ pale-ochreous; in ♀ basal part of disc, except on dorsum, is suffused with fuscous-brown; a fine fuscous-brown subdorsal streak to middle; a transverse streak of similar colour from middle of cell to middorsum; a fuscous-brown spot on three-fifths costa prolonged as fine lines along posterior edge of cell and bases of veins proceeding from it; a similar fine subterminal line also giving off short branches on veins; cilia brown-whitish. Hindwings with termen strongly rounded; pale-brown; cilia pale-brown.

Northwest Australia: Sherlock River; four specimens in the British Museum.

18. Parasa alphaea.

Bombyx alphaea Fab., *Syst. Ent.*, iii (1), p. 445.—*Eloasa calida* Wlk., *Cat. Brit. Mus.*, xxxii, p. 494.—*Doratifera congrua* Wlk., *Char. Undesc. Lep.*, p. 20.—*Lethocephala eremospila* Low., *Trans. Roy. Soc. S. Aust.*, 1902, p. 219.

♂. 28-35 mm. ♀. 32-45 mm. Head, thorax, and abdomen brown, in ♀ reddish-brown. Palpi 1; brown. Antennae pale brown; pectinations in ♂ moderately long from base to beyond middle, thence short to apex, in ♀ more shortly bipectinate to apex. Legs brown. Forewings triangular, costa straight, apex round-pointed, termen rounded, slightly oblique; 10 separate, 7 connate or stalked; brown, in ♀ reddish-brown; a short oblique fuscous streak from one-third dorsum, in ♀ less marked and sometimes obsolete; a fuscous spot in middle of disc at three-fifths, absent in ♀; cilia fuscous-brown or brown. Hindwings with termen rounded; brown, paler towards termen; cilia brown.

Queensland: Emerald, Caloundra, Brisbane.

19. Parasa pyrrhothrix, n. sp.

πυρρόθριξ, reddish-haired.

♂. 40 mm. Head, thorax, and abdomen reddish-brown. Palpi three-fourths; reddish-brown. Antennae reddish-brown; basal pectinations in ♂ long, ceasing abruptly at one-third. Legs brown; posterior tibiae with dense long hairs on dorsum; spurs concealed. Forewings triangular, costa slightly sinuate, apex round-pointed, termen rounded, slightly oblique; 10 separate; brown, becoming paler towards termen, sometimes greyish towards termen; cilia grey-brown. Hindwings with termen rounded; reddish-brown; cilia reddish-brown, apices paler.

North Queensland: Kuranda, near Cairns, in October and April; two specimens received from Mr. F. P. Dodd.

20. Parasa acrata, n. sp.

ἄκρατος, unmixed.

♂, ♀. 34 mm. Head, palpi, thorax, abdomen, and legs grey or ochreous-grey. Antennae ochreous; pectinations in ♂ long from base, gradually shortening beyond middle, but continued to apex, though there very short; in ♀ shortly bipectinate. Forewings triangular, costa straight to near apex, apex round-pointed, termen obliquely rounded; grey, sometimes purplish or ochreous-tinged; without markings; cilia concolorous. Hindwings with termen strongly rounded; pale grey or ochreous-grey-whitish; cilia concolorous.

South Australia: East-West Railway, it may have entered the train at Port Augusta; ♂ type received from Mr. W. B. Barnard. Northwest Australia: Roeburne; one ♀ in Coll. Lyell.

Gen. 5. ECNOMOCTENA nov.

ἐκνομοκτενος, with unusual comb.

Palpi moderate, porrect; second joint shortly rough-haired; terminal joint short or moderate, obtuse. Antennae of ♂ unipectinate, the outer row only being developed, pectinations long towards base, gradually shortening beyond middle, and disappearing at about three-fourths. Tibial spurs moderately long, but partly concealed in long hairs; posterior tibiae with middle spurs present. Forewings with forked median vein in cell, 7, 8, 9 stalked, 10 separate, sometimes approximated at base. Hindwings with single median vein in cell, 6 and 7 connate or stalked, 11 absent, 12 anastomosing shortly with cell near base.

Type, *E. brachyopa* Low. Allied to *Thosea* from which it differs in the peculiar antennae of the ♂. The ♀ is not yet known.

1. Forewing with fuscous postmedian and subterminal lines, the latter dentate .... *brachyopa*
   Forewing without such lines, but with a white line from dorsum half across disc .... *hemitoma*

21. ECNOMOCTENA BRACHYOPA.

Doratiphora brachyopa Low., PROC. LINN. SOC. N.S.W., 1897, p. 10.—*D. grisea* Auriv., *Archiv. f. Zool.*, xiii (2), 1920, p. 35, Pl. i, f. 4.

♂. 22-24 mm. Head ochreous-brown. Palpi dark-brown. Antennae brownish. Thorax reddish-brown. Abdomen ochreous-brown. Legs brownish-grey. Forewings short, broadly triangular, costa straight to near apex, apex rounded, termen rounded, scarcely oblique; reddish-brown, apical area grey, sometimes a whitish-grey fascia between postmedian and subterminal lines; lines fuscous; postmedian from two-thirds costa, at first transverse, bent abruptly inwards beneath cell, again bent and continued transversely, sometimes with a few dentations, to middorsum; preceding first line is an interrupted dark-brown ring on end of cell; subterminal fine and finely dentate, from before apex to tornus; an interrupted fuscous terminal line; cilia grey. Hindwings with termen rounded; 6 and 7 connate; pale-brownish; cilia grey.

An example of *grisea* kindly sent me by Prof. Aurivillius has the forewing wholly grey except annulus, but agrees in structure and pattern.

Northern Territory: Darwin. North Queensland: Cooktown, Cairns. North-west Australia: Kimberley.

22. ECNOMOCTENA HEMITOMA, n. sp.

ἡμιτομος, half-divided.

♂. 26 mm. Head, palpi, antennae, thorax, abdomen, and legs reddish-brown. Forewings triangular, costa straight to near apex, apex rounded, termen somewhat obliquely rounded; reddish-brown; a broad, white, transverse line from mid-dorsum to middle of disc; cilia reddish-brown. Hindwings with termen rounded; 6 and 7 stalked; pale brownish; cilia brownish.

Northern Territory: Darwin in November; two specimens received from Mr. F. P. Dodd.

Gen. 6. THOSEA.

Wlk., *Cat. Brit. Mus.*, v, p. 1068; Hmps. *Moths Ind.*, i, p. 377.

Palpi moderate, porrect, thickened with appressed hairs; terminal joint short, concealed. Antennae of ♂ bipectinate to apex, with only gradual shortening in

terminal one-fourth. Tibial spurs long, not concealed; posterior tibiae with two pairs of spurs. Forewings with forked median vein in cell, 7, 8, 9 stalked or 7 connate or approximated. Hindwings with a single median vein in cell, costal edge of cell over four-fifths, 6 and 7 stalked, 11 absent, 12 anastomosing with cell near base.

Type, *T. unifascia* Wlk. from India. In *T. ordinata* 7 of forewings may be either approximated, connate, or stalked.

1. Forewings with an oblique dark line from mid-dorsum to costa before apex .. *penthima*
   Forewings with a subterminal line of dark spots .... *ordinata*

23. Thosea penthima.

Turn., *Trans. Roy. Soc. S. Aust.*, 1902, p. 206.—*Dasycomota pyrrhoea* Low., *ibid.*, p. 220.

Northern Territory: Darwin, Daly River. North Queensland: Claudie River, Cooktown, Cairns, Herberton, Townsville, Bowen.

24. Thosea ordinata.

Doratifera ordinata Butl., *Trans. Ent. Soc.*, 1896, p. 388.—*Doratiphora colligans* Luc., *Proc. Roy. Soc. Qld.*, 1901, p. 76.

♂. 26-33 mm. Head pale ochreous, sometimes with a few fuscous scales on sides of face. Palpi $1\frac{1}{2}$; pale ochreous, sometimes brownish-tinged. Antennae pale ochreous; pectinations in ♂ moderately long at base, gradually diminishing to apex. Thorax, abdomen, and legs pale ochreous. Forewings triangular, costa straight or slightly sinuate, apex rounded, termen rounded, slightly oblique; pale ochreous, sometimes with some basal fuscous irroration; a slightly darker, obliquely transverse, median line, usually incomplete, sometimes followed by a second line; a subterminal series of closely approximated, squarish, dark brown spots; cilia pale ochreous. Hindwings with termen strongly rounded; pale ochreous; cilia pale ochreous.

Northern Territory: Alexandria. North Queensland: Townsville. Queensland: Clermont, Emerald, Brisbane, Toowoomba, Jandowae.

Gen. 7. Chalcoscelis.

Chalcocelis Hmps., *Moths Ind.*, i, p. 392 (misprint of *Chalcoscelis*).

χαλκοσκελης, with brassy legs.

Palpi short, ascending, appressed to frons, covered with smoothly appressed hairs. Antennae in ♂ bipectinated towards base, pectinations long, apical half simple. Forewings with a single median vein in cell, 7, 8, 9 stalked, 10 connate from upper angle of cell. Hindwings with a single median vein in cell, costal edge of cell two-thirds to three-fourths, discocellulars with acute basal angle, 6 and 7 approximated at origin, connate, or short-stalked, 11 absent, 12 anastomosing with cell before middle.

1. Hindwings in ♂ fuscous, in ♀ ochreous .... *fumifera*
   Hindwings in ♂ pale reddish-brown .... *castanica*

25. Chalcoscelis fumifera.

Miresa fumifera Swin., *Trans. Ent. Soc.*, 1890, p. 195, Pl. 6, f. 13.—♀ *Doratiphora hemistaura* Low., *Trans. Roy. Soc. S. Aust.*, 1902, p. 215.—♂ *D. nephrochrysa* Low., *ibid.*, p. 218.

♂. 26-28 mm. Head fuscous-brown. Palpi $1\frac{1}{4}$; ochreous-brown; outer surface fuscous-brown. Antennae fuscous; with long pectinations at base, ceasing

abruptly about middle. Thorax and abdomen fuscous-brown. Legs fuscous-brown; coxae and femora ochreous. Forewings triangular, costa straight to near apex, apex round-pointed, termen slightly rounded, oblique; fuscous-brown, a rather large dark reddish-brown spot above dorsum before middle with a white dot on its anterior-superior edge; a fuscous discal dot beyond middle; cilia paler fuscous-brown. Hindwings with termen slightly rounded; fuscous; cilia fuscous, sometimes with indistinct whitish bars.

♀. 38 mm. Head brownish-ochreous. Palpi 1½; brownish-ochreous. Antennae ochreous. Thorax brownish-ochreous, with some long fuscous-tipped scales anteriorly. Abdomen and legs brownish-ochreous. Forewings suboval, costa gently arched, apex rounded, termen obliquely rounded; pale brownish-ochreous; some fuscous suffusion near base; a trilobate reddish-brown blotch between dorsum and cell, its anterior edge white; a blackish discal dot about middle; a fine, irregularly crenulate, brown line, outwardly-curved, from three-fourths costa to termen below middle; a fine brown terminal line; cilia pale brownish with an interrupted darker median line. Hindwings with termen rounded; ochreous; cilia ochreous with an indistinct darker antemedian line.

North Queensland: Cairns, Mackay. Also from Borneo, Malay Peninsula, and India.

26. Chalcoscelis castanica, n. sp.

κάστανικος, chestnut-brown.

♂. 26 mm. Head and palpi reddish-brown. Antennae reddish-brown; pectinations long toward base, abruptly disappearing about middle, thence simple. Thorax and abdomen reddish-brown. Legs densely hairy; reddish-brown. Forewings triangular, costa straight, apex pointed, termen very slightly rounded, oblique, dorsum shorter than termen; reddish-brown; an irregular spot of darker reddish-brown above one-third dorsum, containing a white dot at its anterior superior angle; a fuscous discal dot beyond middle at end of cell; cilia reddish-brown. Hindwings with termen slightly rounded; pale reddish-brown; cilia somewhat paler.

Type in Coll. Lyell.

North Queensland: Cape York (Elgner), one specimen in September.

Gen. 8. Anepopsia, nov.

ἀνεπόψιος, inconspicuous.

Palpi long (2 or more), obliquely ascending, thickened with appressed hairs. Antennae in ♂ with long pectinations continued to apex with only gradual shortening in terminal one-fourth. Tibial spurs moderate; not concealed; posterior tibiae with terminal spurs only. Forewings with a single or forked median vein in cell, 7, 8, 9, stalked. Hindwings with a single or forked median vein in cell, costal edge of cell almost as long as dorsal, 6 and 7 connate or short-stalked, 11 absent, 12 anastomosing with cell near base, sometimes a series of short costal pseudoneuria.

Differs from *Parasa* in ♂ antennae being bipectinate to apex with only gradual reduction of length in terminal one-fourth, from *Thosea* in the absence of middle-spurs, and from both in the long ascending palpi. Type, *A. tephraea.*

1. Forewings without markings .... *tephraea*
   Forewings with dark postmedian line .... *eugyra*

27. ANEPOPSIA TEPHRAEA, n. sp.

τεφραιος, ash-coloured.

♂. 30 mm. Head, palpi, thorax, abdomen, and legs grey. Antennae grey; pectinations in ♂ ochreous-tinged, long, becoming shorter in apical one-fourth. Forewings triangular, costa straight, apex tolerably pointed, termen bowed, oblique; grey; cilia grey. Hindwings with termen rounded; grey; cilia grey.

Queensland: Charleville in December; one specimen.

28. ANEPOPSIA EUGYRA, n. sp.

εὔγυρος, well-rounded.

♂. 22 mm. Head, palpi, thorax, abdomen, and legs pale-grey. Antennae pale-grey; pectinations in ♂ long, becoming gradually shorter in apical one-third. Forewings broadly triangular, costa straight to near apex, apex rounded, termen obliquely rounded; pale-grey; a slightly curved darker line from three-fifths dorsum nearly to apex; cilia pale-grey. Hindwings with termen rounded; grey; cilia grey.

Type in Coll. Goldfinch.

North Queensland: Meringa, near Cairns in November; one specimen.

Gen. 9. HYPOBLECHRA, nov.

ὑποβληχρός, rather feeble.

Palpi moderately long, ascending; thickened with appressed hairs; terminal joint short. Antennae in ♂ bipectinate towards base, pectinations long, towards apex simple. Tibial spurs moderate, not concealed; posterior tibiae without middle spurs. Forewings with a single median vein in cell, 7 separate, 8, 9, 10 stalked. Hindwings with a single median vein in cell, costal edge of cell four-fifths or more, 6 and 7 connate or stalked, 11 absent, 12 anastomosing with cell near base.

Type, *H. delocrossa* Turn. A development of *Birthama* differing in the loss of middle-spurs. Both the species are of small size.

1. Forewings with a pale line parallel with and close to termen .... *delocrossa*
   Forewings without pale line close to termen .... *haplopis*

29. HYPOBLECHRA DELOCROSSA.

Birthama delocrossa Turn., *Trans. Roy. Soc. S. Aust.*, 1906, p. 139.

North Queensland: Cairns.

30. HYPOBLECHRA HAPLOPIS.

Birthama haplopis Turn., *Trans. Roy. Soc. S. Aust.*, 1906, p. 139.

North Queensland: Cairns.

Gen. 10. BIRTHAMA.

Birthama Wlk., *Journ. Linn. Soc.*, vi, 1862, p. 175; Hmps., *Moths India*, i, p. 386.

Palpi short or moderate, porrect or obliquely ascending, thickened with appressed hairs; terminal joint short, concealed. Antennae in ♂ bipectinate towards base, pectinations long, towards apex simple. Tibial spurs moderate, not concealed; posterior tibiae with two pairs of spurs. Forewings with a single median vein in cell, 7 separate, 8, 9, 10 stalked. Hindwings with a single median vein in cell, costal edge of cell four-fifths or more, 6 and 7 connate or stalked, 11 absent, 12 anastomosing with cell near base or before middle.

Type, *B. obliqua* Wlk., from Borneo. According to Hampson the ♂ has only one pair of spurs on the posterior tibiae, the ♀ two pairs; but I suspect an error of observation. In the Australian species the spurs are equally developed in both sexes.

1. Forewings without whitish markings .... *plagioscia*
   Forewings with white discal dot or whitish lines 2
2. Forewings with white discal dot or oblique whitish line .... *modesta*
   Forewings with transverse whitish lines from costa and dorsum halfway across disc .... *ocularis*

31. Birthama plagioscia.

Turn., *Trans. Roy. Soc. S. Aust.*, 1902, p. 190.—*Doratiphora aspidophora* Low., *ibid.*, p. 281.

Queensland: Brisbane, Stradbroke Island.

32. Birthama modesta.

♂. *Pygmaeomorpha modesta* B-Bak., *Novitates Zoolog.*, 1904, p. 387, Pl. 5, f. 35 (September).—♂ *Birthama leucosticta* Turn., *Trans. Roy. Soc. S. Aust.*, 1904, p. 241. ♀ *B. dochmographa* Turn., *ibid.*, p. 241.

Mr. Bethune-Baker's name has a few months' priority. The sexes are strikingly dissimilar.

Northern Territory: Darwin. North Queensland: Thursday Island, Claudie River, Cairns, Innisfail. Also from New Guinea.

33. Birthama ocularis.

Bombyx ocularis Luc., *Trans. Nat. Hist. Soc. Qld.*, 1894, p. 104.—*Doratiphora eumela* Low., *Trans. Roy. Soc. S. Aust.*, 1896, p. 153.—*Birthama discotypa* Turn., *Trans. Roy. Soc. S. Aust.*, 1902, p. 190.

Northern Territory: Darwin. North Queensland: Cairns, Mackay. Queensland: Brisbane.

Gen. 11. Anapaea.

Wlk., *Cat. Brit. Mus.*, v, p. 1117.

Palpi very short, porrect, hairy. Antennae of ♂ bipectinate towards base, pectinations long, apical one-half simple. Tibial spurs short, concealed; posterior tibiae without middle spurs. Forewings with a single median vein in cell, 7, 8, 9 stalked, 10 separate or connate. Hindwings with a single median vein in cell, costal edge of cell but little shorter than dorsal, 6 and 7 widely separate at origin, 11 absent, 12 anastomosing with cell near base, a series of many fine pseudoneuria running from 12 towards costa.

Type, *A. denotata* Wlk.

34. Anapaea denotata.

Wlk., *Cat. Brit. Mus.*, xxxii, 1865, p. 474.

♂. 20-28 mm. ♀. 28-34 mm. Head reddish-brown; face pale-ochreous. Palpi ½; pale-ochreous. Antennae reddish-brown; in ♂ with long pectinations at base, ceasing abruptly about middle. Thorax reddish-brown, sometimes partly grey-whitish. Abdomen reddish-brown. Legs reddish-brown or pale-ochreous. Forewings triangular, costa straight to near apex, or slightly arched in ♀, apex rounded, termen obliquely rounded; reddish-brown, sometimes ochreous-grey; sometimes one or two slender transverse sub-basal lines partially developed; three darker

spots arranged in an oblique line between one-fourth dorsum and cell, more or less edged with whitish; usually several similar dots beneath midcosta; two postmedian and a subterminal transverse line paler or whitish; a whitish suffused line around apex; cilia reddish-brown, sometimes indistinctly barred, apices paler. Hindwings with termen strongly rounded; in ♂ dark-brown, in ♀ brownish-ochreous; cilia ochreous, apices in ♂ sometimes whitish.

Northern Territory: Darwin. North Queensland: Cairns, Atherton, Townsville. Queensland: Brisbane, Coolangatta, Toowoomba, Dalby. New South Wales: Sydney, Jervis Bay. Victoria: Melbourne, Sea Lake. Western Australia: Perth. Examples from Brisbane and northwards are smaller and darker, those from Sydney and southwards larger and paler.

Gen. 12. Scopelodes.

Westw., *Nat. Libr.*, 37 (Ent. vii), 1841, p. 222.

Antennae in ♂ bipectinate, pectinations long towards base, shortening about middle, and gradually disappearing leaving terminal one-fourth simple. Palpi very long, porrect or ascending; second joint long, thickened with appressed hairs; terminal joint very long, ending in a strong terminal tuft of long hairs dilated at apex. Legs including tarsi densely rough-haired; tibial spurs long but concealed; posterior tibiae without middle spurs. Forewings with a single median vein in cell, 7, 8, 9, 10 stalked or 10 separate, 11 from near end of cell. Hindwings with a single median vein in cell, costal edge of cell about four-fifths, 6 and 7 connate or stalked, 11 present but very short, 12 approximated to cell before middle but not anastomosing, a series of costal pseudoneuria.

Type, *S. unicolor* Westw. from India.

35. Scopelodes nitens.

B-Bak., *Novitates Zoolog.*, 1904, p. 385, Pl. 5, f. 51.

♂. 38-40 mm. Head whitish. Palpi ochreous-grey; terminal tuft whitish, extreme apex fuscous. Antennae pale-ochreous. Thorax whitish, posteriorly ochreous-tinged. Abdomen ochreous. Legs very hairy; pale-grey. Forewings triangular, termen straight to near apex, apex rounded, termen obliquely rounded; shining ochreous-grey with some transverse corrugations; cilia ochreous-grey. Hindwings with termen strongly rounded; ochreous; cilia ochreous.

North Queensland: Banks Island in Torres Strait (W. McLennan) in January, two specimens taken at light, received from the Australian Museum. Also from New Guinea.

Gen. 13. Anaxidea.

Swin., *Cat. Oxf. Mus.*, i, 1892, p. 231.

Palpi short or moderate, porrect, thickened with appressed hairs or loosely hairy; terminal joint short, concealed. Antennae of ♂ bipectinate towards base, towards apex simple. Tibial spurs short, sometimes concealed; posterior tibiae with terminal spurs only. Forewings with a single median vein in cell, 7, 8, 9 stalked, 10 separate, connate, or stalked. Hindwings with a single median vein in cell, dorsal edge of cell four-fifths or more, 6 and 7 stalked, 11 present, from about middle of cell, running into 12, which is separate, a costal series of fine pseudoneuria.

Type, *A. lactea* Swin. It is probable that further study of the extra-Australian species will discover an older name for this genus.

1. Forewings with oblique line 2
Forewings without oblique line .... *integer*
2. Forewings with finely dentate oblique line 3
Forewings with oblique line not dentate .... *loxogramma*
3. Wings whitish or grey-whitish .... *lactea*
Wings brown .... *dochmosema*

36. ANAXIDEA LACTEA.

Swin., *Cat. Oxf. Mus.*, i, 1892, p. 231.—*Susica aerogramma* Low., PROC. LINN. SOC. N.S.W., 1915, p. 477.

♂. 32-34 mm. ♀. 38-42 mm. Head, thorax, and abdomen whitish or grey-whitish; sides of face fuscous. Palpi less than 1, loose-haired; fuscous, apices ochreous. Antennae ochreous; pectinations in ♂ moderate, shortening gradually beyond middle and ceasing before apex. Legs whitish or grey-whitish; tarsi ochreous barred with fuscous. Forewings triangular, costa straight, apex round-pointed, termen slightly rounded, oblique; 10 separate or connate; whitish or grey-whitish; costal edge sometimes ochreous-tinged; a dark fuscous, finely dentate, oblique line from dorsum before middle to three-fourths costa, obsolete or slightly angled beneath costa; cilia concolorous. Hindwings with termen rounded; colour as forewings.

South Australia: Purnong, Pinnaroo, Ooldea. Western Australia: Albany, Perth, Mullewa.

37. ANAXIDEA DOCHMOSEMA.

Susica dochmosema Turn., *Trans. Roy. Soc. S. Aust.*, 1902, p. 191.

Queensland: Rockhampton.

38. ANAXIDEA LOXOGRAMMA.

Parasa loxogramma Turn., *Trans. Roy. Soc. S. Aust.*, 1902, p. 193 and 1906. p. 138.

♂. 28-33 mm. ♀. 36-38 mm. Head, thorax, and abdomen brown, ochreous-brown, or grey. Palpi 1½; brown or grey; thickened with appressed hairs. Antennae pale-brown; in ♂ with moderate pectinations gradually shortening beyond middle, apices simple. Legs brown or grey. Forewings triangular, costa straight in ♂, nearly so in ♀; apex pointed, termen rounded, slightly oblique; 10 connate or stalked; brown, ochreous-brown, greyish-brown, or grey; a nearly straight oblique dark line from dorsum near base to apex, sometimes pale-edged posteriorly, sometimes a pale line only; a dark median discal dot immediately beyond this line; a similar inwardly-curved line from apex to termen shortly above tornus; cilia brown or grey, apices paler. Hindwings with termen rounded; brown, ochreous-brown, greyish-brown, or grey; cilia concolorous.

Variable in colour but easily recognized.

North Queensland: Herberton, Atherton. Queensland: Brisbane, Mt. Tambourine, National Park (3,000 ft.), Toowoomba. New South Wales: Lismore, Dorrigo, Barrington Tops, Sydney.

39. ANAXIDEA INTEGER, n. sp.

integer, without markings.

♀. 38 mm. Head, palpi, and thorax pinkish-white. Antennae ochreous-whitish; in ♀ shortly bipectinate, becoming simple towards apex. Abdomen and legs pinkish-white. Forewings triangular, costa nearly straight, very slightly sinuate, apex rounded, termen rounded, oblique; 8 connate, 10 separate; pinkish-

white without markings; cilia ochreous-whitish, apices pale pinkish-fuscous. Hindwings with termen rounded; whitish; cilia whitish.

Type in South Australian Museum.

Northwest Australia: Hammersley Range (W. D. Dodd).

Gen. 14. HEDRAEA, nov.

ἑδραῖος, sedentary.

Palpi very long (about 4), porrect, loose-haired; terminal joint long. Tibial spurs long, not concealed; posterior tibiae with middle spurs. Forewings with forked median vein in cell, 7 connate or stalked with 8, 9, 10 separate. Hindwings with single median vein in cell, costal edge of cell almost as long as dorsal, 6 and 7 connate or approximated at origin, 11 present but short, 12 approximated to cell before middle but not anastomosing, a series of costal pseudoneuria.

40. HEDRAEA QUADRIDENS.

Doratiphora quadridens Luc., *Proc. Roy. Soc. Qld.*, 1901, p. 77.

♀. 42 mm. Head, thorax, abdomen, and legs whitish-ochreous. Palpi long (4), porrect, ochreous-whitish. Antennae ochreous-whitish. Forewings triangular, costa gently arched, apex rounded-rectangular, termen nearly straight, slightly oblique; very pale ochreous; a transverse series of 4 or 5 white spots in disc at two-thirds, surrounded by a brown suffusion; costal edge brown; cilia pale-ochreous. Hindwings with termen rounded; colour as forewings. Underside whitish-ochreous; forewings with discal spots indicated; hindwings with a brown discal dot before middle.

Queensland: Brisbane, Stradbroke Island.

Gen. 15. ELASSOPTILA.

Turn., *Trans. Roy. Soc. S. Aust.*, 1902, p. 206.

Palpi very long (over 6), porrect; second joint very long, thickened with appressed hairs; terminal joint long. Antennae of ♂ with a double row of long pectinations continued almost to apex (apical one-tenth simple); of ♀ simple. Thorax and abdomen slender. Legs smooth; tibial spurs very long; posterior tibiae with two pairs of spurs. Forewings with median vein obsolete, 7, 8, 9 stalked. Hindwings with median vein obsolete, costal edge of cell not much shorter than dorsal, 6 and 7 stalked, 11 present from middle of cell running into 12 which is separate.

Type, *E. microxutha* Turn. Remarkable in this family for its slender build, small size, with which the obsolescence of the median veins is correlated, smooth legs, long palpi, and long tibial spurs. It is, however, a true Limacodid and the neuration of the hindwings is primitive.

41. ELASSOPTILA MICROXUTHA.

Turn., *Trans. Roy. Soc. S. Aust.*, 1902, p. 206.

Queensland: Mt. Tambourine, National Park (3,000 ft.). New South Wales: Lismore.

Gen. 16. HYPSELOLOPHA, nov.

ὑψηλόλοφος, with high crest.

Palpi moderately long, ascending, thickened with appressed hairs; terminal joint short. Antennae of ♂ bipectinate towards base, towards apex simple. Thorax with a large postmedian and a smaller posterior crest. Tibial spurs moderately

long, not concealed; posterior tibiae with two pairs of spurs. Forewings with a single median vein in cell, 7, 8, 9 stalked, 10 connate or short-stalked. Hindwings with a single median vein in cell, cell short (about one-third), 6 and 7 stalked, 11 present but short, 12 rather closely approximated to cell towards base.

42. Hypselolopha hypodrosa, n. sp.

ὑπόδρωσος, somewhat dewy.

♂. 28 mm. Head white. Palpi 1½; brown. Antennae brown; pectinations in ♂ moderately long, ceasing rather abruptly at two-thirds. Thorax whitish partly suffused with brown; posterior crest brown. Abdomen brown. Legs whitish-brown. Forewings triangular, costa slightly arched, apex round-pointed, termen nearly straight, slightly oblique; brown; base and middle of disc broadly suffused with whitish; an irregular, obliquely crescentic, dark-brown, discal mark beyond middle; a line of whitish suffusion, interrupted by veins, along termen; cilia pale-brown. Hindwings with termen rounded; ochreous-whitish becoming brown towards termen; cilia ochreous, apices whitish.

A species of unusual structure and *facies.*

North Queensland: Evelyn Scrub, near Herberton, in February; one specimen received from Mr. F. P. Dodd.

Gen. 17. Susica.

Wlk., *Cat. Brit. Mus.*, v, p. 1113.

Palpi moderate, porrect, or somewhat ascending, clothed with appressed or rather loose hairs; terminal joint short. Antennae of ♂ bipectinate towards base, pectinations long, usually shortening abruptly about middle, terminal part of antennae usually simple, but sometimes pectinations extend to apex, shortening gradually; in ♀ simple. Forewings with forked median vein in cell, 7 connate or stalked, 10 separate, connate, or stalked. Hindwings with 11 from near base running into 12, costal pseudoneuria sometimes present.

Type, *S. pallida* Wlk., from India.

1.	Forewings marked or tinged with red	2
	Forewings not marked or tinged with red	5
2.	Forewings with many distinct red lines	3
	Forewings more or less suffused with red	4
3.	Forewings without defined transverse lines	*resplendens*
	Forewings with two fuscous transverse lines	*miltogramma*
4.	Forewings with oblique fuscous line	*cosmocalla*
	Forewings without oblique line	*miltocosma*
5.	Wings white	*collaris*
	Wings not white	6
6.	Forewings with oblique line or lines	7
	Forewings without oblique lines	9
7.	Forewings with two pale oblique lines	*euryparoa*
	Forewings with one oblique line	8
8.	Wings pale-ochreous	*kenricki*
	Wings grey-whitish	*placerodes*
9.	Forewings with a dark-fuscous subterminal line	*fasciata*
	Forewings without subterminal line	10
10.	Forewings with base of costa white	*humeralis*
	Forewings with base of costa not white	11
11.	Wings pale-ochreous	12
	Wings chestnut-brown	*uniformis*
12.	Forewings narrow	*liosarca*
	Forewings broad	*monomorpha*

43. SUSICA RESPLENDENS, n. sp.

resplendens, brilliant.

♂. 32-34 mm. Head bright-red. Palpi 1½; ochreous, upper surface red. Antennae pale-ochreous; pectinations in ♂ very long towards base, ceasing abruptly about middle. Thorax grey; outer edge and two longitudinal lines bright-red. Abdomen grey-whitish. Legs red; ventral surface whitish; posterior pair mostly whitish. Forewings elongate-triangular, costa straight to near apex, apex rounded, termen nearly straight, rounded beneath, scarcely oblique; 7, 8, 9 stalked, 10 connate or stalked; grey with broad longitudinal bright-red streaks; a fine costal streak partly or wholly confluent with a broad subcostal streak from base to apex; from subcostal near base arises a median streak extending as far as middle, dilated posteriorly; a fine streak between the two preceding; a streak from base along fold to tornus, dilated before middle to dorsal edge, then interrupted; a series of short interneural streaks beyond cell; a bright-red terminal line; a slight dark fuscous irroration on mid-dorsum, sometimes forming an obscure oblique line in disc; cilia whitish-grey. Hindwings with termen rounded; pale red; cilia whitish-grey. Underside except cilia red.

Allied to *S. miltogramma*, differing in the longer palpi, red head, absence of ochreous tinge in wings and their cilia, almost complete absence of dark fuscous lines, and the whitish abdomen.

Northern Territory: Darwin (Batchelor) in October; two specimens received from Mr. G. F. Hill.

44. SUSICA MILTOGRAMMA.

Momopola miltogramma Meyr., *Trans. Roy. Soc. S. Aust.*, 1891, p. 190.—*Darala rosea* Luc., PROC. LINN. SOC. N.S.W., 1891, p. 291.—*Hildala miniacea* Swin., *Cat. Oxf. Mus.* i, 1892, p. 232.

Mr. N. B. Tindale informs me that Meyrick's name has a few weeks' priority. Forewings with 7, 8, 9 stalked, 10 connate or stalked.

Northern Territory: Darwin, Port Essington. North Queensland: Cooktown, Cairns, Mareeba.

45. SUSICA COSMOCALLA.

Momopola cosmocalla Low., *Trans. Roy. Soc. S. Aust.*, 1902, p. 220.

♂, ♀. 35-40 mm. Head rosy. Palpi rosy, apex usually fuscous. Antennae whitish-ochreous; pectinations in ♂ 4, apical two-fifths serrate. Thorax rosy mixed with whitish-grey. Abdomen grey-whitish. Legs whitish; dorsum of femora, tibiae, and anterior coxae more or less rosy; tibiae and tarsi annulated with blackish. Forewings triangular, costa strongly arched, apex rounded, termen obliquely rounded; 7, 8, 9 stalked, 10 connate or stalked; rosy suffused, except on margins, with grey-whitish; an oblique dark-fuscous line from mid-dorsum nearly to four-fifths costa; cilia grey-whitish, apices rosy. Hindwings with termen strongly rounded; whitish; in ♀ rosy-tinged towards termen; cilia grey-whitish, apices whitish.

When describing *S. miltocosma* from a ♀ type I thought that this species, which I had seen, might be its ♂, but I have now both sexes of both species. Mr. Lower appears also to have included both species in his description.

North Queensland: Claudie River. Queensland: Rockhampton, Duaringa, Gayndah.

46. Susica miltocosma.

Turn., *Trans. Roy. Soc. S. Aust.*, 1902, p. 191.

♂. 35 mm. ♀. 40 mm. Head grey; face red in ♂, with red margins in ♀. Palpi 1¼; red. Antennae pale-grey; pectinations in ♂ rather long, ceasing abruptly at about three-fifths. Thorax reddish-grey. Abdomen white. Legs whitish; dorsum of anterior pair red with tarsi barred with black. Forewings elongate-triangular, costa nearly straight in ♂, gently arched in ♀, apex rounded-rectangular, termen slightly rounded, slightly oblique; 7, 8, 9 stalked, 10 connate or stalked; reddish-grey; a red costal streak, broad in ♂, slender in ♀; terminal edge sometimes reddish-tinged; cilia grey. Hindwings with termen rounded; white; cilia white. Underside white; forewings suffused with red along costa and termen.

The sexes are similar.

North Queensland: Townsville, Mackay. Queensland: Westwood.

47. Susica collaris.

Comana collaris Wlk., *Cat. Brit. Mus.*, xxxii, p. 496.

♂. 36-45 mm. ♀. 50-65 mm. Head white; lower edge of face reddish-brown. Palpi 1; reddish-brown. Antennae pale-brown; pectinations in ♂ rather long, shortening rapidly beyond middle, apical two-fifths simple. Thorax white; collar reddish-brown, anterior edge sometimes fuscous. Abdomen white. Legs reddish-brown; tibiae and tarsi with blackish bars. Forewings elongate-triangular, costa in ♂ straight, in ♀ slightly arched, apex round-pointed, termen slightly rounded, oblique; 7, 8, 9 stalked, 10 connate or stalked; white; cilia white. Hindwings with termen rounded; white; cilia white.

Perfectly fresh specimens are faintly tinged with green, but this soon fades away.

Northern Territory: Mary River. North Queensland: Cairns, Atherton, Herberton, Townsville. Queensland: Clermont, Westwood, Eidsvold, Gayndah, Brisbane, Charleville. Northwest Australia: Hammersley Range.

48. Susica fasciata.

Teara fasciata Wlk., *Cat. Brit. Mus.*, iv, p. 851.—*Mecytha semicana* Wlk., *ibid.*, v, p. 1121.—*Apoda xylomeli* Scott, *Aust. Lep.*, p. 19, Pl. vi.

♂. 32-38 mm. ♀. 39-46 mm. Head brown, sometimes mixed with white. Palpi about 1; dark-brown. Antennae brown; pectinations in ♂ moderate, gradually shortening from middle, not reaching apex. Thorax brown, sometimes mixed or even largely replaced by white. Abdomen fuscous; tuft white. Legs brown more or less mixed with white; tibiae and tarsi barred with fuscous. Forewings elongate-triangular; costa straight, apex rounded, termen slightly rounded, scarcely oblique; 7, 8, 9 stalked, 10 separate; fuscous-brown; apical area usually more or less suffused with white, in ♂ the whole of terminal and dorsal areas may be white; a darker dentate line from two-thirds costa, at first transverse, bent inwards beneath middle, and again bent to end on mid-dorsum, sometimes partly obsolete; a similar but less dentate subterminal line from costa, curved outwards beneath costa, then inwards, and again outwards, ending at tornus; cilia brown more or less mixed with white. Hindwings with termen rounded; fuscous-brown; a white terminal line from costa not reaching tornus; cilia white, sometimes with dark spots or bars. Underside of both wings fuscous with white terminal lines.

Very variable in the amount of white on upper surface of forewings and thorax.

Northern Territory: Darwin, Stapleton. North Queensland: Herberton, Townsville. Queensland: Caloundra, Brisbane, National Park (3,000 ft.). New South Wales: Lismore, Newcastle, Sydney, Jervis Bay.

49. Susica humeralis.

Miresa humeralis Wlk., *Cat. Brit. Mus.*, xxxii, p. 477.—*M. albibasis* Wlk., *Trans. Ent. Soc.*, 1862, p. 274.

♂. 41-45 mm. ♀. 50-52 mm. Head and thorax reddish-ochreous-brown. Palpi 1, porrect; reddish-ochreous-brown. Antennae brown; pectinations in ♂ moderately long, becoming short about middle, and ceasing at three-fourths. Abdomen ochreous-brown. Legs ochreous-brown; tibiae and tarsi usually more or less mixed with fuscous. Forewings suboval, costal slightly arched, apex rounded, termen obliquely rounded; 7, 8, 9 stalked, 10 usually connate sometimes stalked; ochreous-brown with a few scattered whitish scales; a white spot on base of costa, usually prolonged along costal edge for a short distance; cilia ochreous-brown. Hindwings with termen rounded; as forewings, but rather paler.

Two males from the Northern Territory have the whitish irroration on forewings more pronounced than usual and forming a terminal series of whitish spots; while the white basal dot is not produced along costa. This is, I think, only a local race.

The species has been identified with *Bombyx corones* Fab. (*Syst. Ent.* iii (1), p. 463), but it is only necessary to quote the following sentence of his description to show that it refers to a very different insect: "Alae anticae cinereae margine exteriore sanguineo, posticae niveae striga postica fusca".

Northern Territory: Darwin, King River. North Queensland: Cairns, Cardwell. Queensland: Duaringa, Westwood, Clermont, Emerald, Eidsvold, Brisbane, Toowoomba.

50. Susica liosarca.

Doratiphora liosarca Low., *Trans. Roy. Soc. S. Aust.*, 1902, p. 217.

♂, ♀. 26-30 mm. Head, thorax, and abdomen ochreous-brown. Palpi 1½, loose-haired; ochreous-brown. Antennae with a tuft of hairs on lower surface of first joint; ochreous-brown; in ♂ with moderately long pectinations continued to apex; in ♀ simple. Legs brown. Forewings semi-oval, costa nearly straight, apex round-pointed, termen slightly rounded, oblique; 7 connate or stalked, 10 separate; ochreous-brown or orange-brown; usually a few fuscous scales which are arranged in a curved line beneath and beyond disc, and sometimes form also a subdorsal and a subapical dot; cilia brown. Hindwings with termen rounded; like forewings, but paler.

Northern Territory: Darwin. North Queensland: Thursday Island, Claudie River. Northwest Australia: Derby.

51. Susica monomorpha.

Natada monomorpha Turn., *Trans. Roy. Soc. S. Aust.*, 1904, p. 242.

North Queensland: Townsville.

52. Susica placerodes, n. sp.

πλᾳκερώδης, broad.

♂. 48 mm. ♀. 60 mm. Head, thorax, and abdomen grey-brown. Palpi 1¼; curved upwards, smooth-haired; grey-brown. Antennae grey-brown; in ♂ with moderately long pectinations from base, shortening about middle, passing into serrations towards apex, in ♀ simple towards base, serrate towards apex. Legs grey-brown; anterior tibiae and first three tarsal joints with white dorsal apical dots. Forewings triangular, costa gently arched, apex rounded, termen obliquely rounded; 7 connate or stalked, 10 connate or separate; grey-whitish with sparsely scattered dark fuscous scales; base in ♂ suffused with grey-brown, a dark grey-brown oblique line from one-third dorsum to two-thirds costa in ♂ passing through a whitish area, in ♀ edged posteriorly with whitish; apical area in ♂ suffused with grey-brown, in ♀ with grey-whitish with a sharp straight anterior edge; cilia grey. Hindwings with termen rounded; pale grey; cilia grey.

North Queensland: Kuranda, near Cairns, in March and April; two specimens received from Mr. F. P. Dodd.

53. SUSICA EURYPARoA, n. sp.

εὐρυπαρῳός, broadly reddish-brown.

♀. 36 mm. Head and palpi ochreous mixed with reddish-brown. Antennae brown; basal joint with a whitish tuft of scales beneath. Thorax reddish-brown. Abdomen brown. Legs brown; anterior femora, tibiae, and first three tarsal joints with white apical anterior bar. Forewings oval-triangular, costa nearly straight, apex and termen very obtusely rounded; brown; two pale whitish-brown lines; first straight, from one-fourth dorsum almost reaching midcosta; second from beneath five-sixths costa to termen above tornus, slightly outwardly curved; some paler suffusion posterior to first line; cilia brown. Hindwings with termen rounded; pale-brown; cilia pale-brown.

Type in Coll. Lyell.

North Queensland: Cape York (Elgner), one specimen in November.

54. SUSICA KENRICKI.

Lasiolimacos kenricki B-Bak., *Novitates Zoolog.*, 1904, p. 388, Pl. vi, f. 33.

♂, ♀. 38-45 mm. Head brown. Palpi ascending, 1¼; brown. Antennae ochreous-brown; in ♂ with long basal pectinations, shortening abruptly in middle, thence very short and replaced by serrations towards apex. Thorax pale ochreous-brown. Abdomen pale ochreous. Legs ochreous-brown; posterior tibiae and tarsi with fuscous bars. Forewings broadly triangular, costa nearly straight, apex rounded, termen rounded, scarcely oblique; 7, 8, 9 stalked, 10 connate; pale ochreous sparsely irrorated with brown; a fuscous discal dot beyond middle; a fine oblique brown line from two-fifths dorsum to apex; a similar line from apex to termen slightly above tornus; cilia pale ochreous, apices brown. Hindwings with termen rounded; pale ochreous; cilia as forewings.

North Queensland: Cape York, Cairns. Also from New Guinea.

55. SUSICA UNIFORMIS.

Hildala uniformis Swin., *Cat. Oxf. Mus.*, i, p. 232.

♂. 25 mm. Head, palpi, thorax, and abdomen chestnut-brown. Antennae brown; pectinations in ♂ 4, gradually shortening to apex. Legs chestnut-brown. Forewings short and broad, costa gently arched, apex rounded-rectangular, termen slightly bowed, not oblique; uniform chestnut-brown; cilia concolorous. Hindwings with termen strongly rounded; colour as in forewings but paler; cilia concolorous.

North Australia: Port Essington. One specimen, the type, in the Oxford Museum.

Unrecognized Species.

56. *Apoda infrequens* Scott., *Aust. Lepid.*, p. 20, Pl. vi.
57. *Doratiphora perixera* Low., *Trans. Roy. Soc. S. Aust.*, 1902, p. 216.
58. *Susica mjöbergi* Auriv., *Arkiv. f. Zool.*, xiii (2), 1920, p. 37.

Index to Limacodidae.

GENERA.

SPECIES.

(Synonyms and unrecognized species in italics.)

Fam. Zygaenidae.

Tongue present (absent in a few exotic genera). Palpi moderate or short. Tibial spurs short or absent; middle spurs always absent. Forewings sometimes with all veins arising separately from cell, areole always absent, often a median vein in cell, sometimes forked, vein 1 developed throughout. Hindwings with 1 present, usually a median vein in cell, 11 from middle of cell, or from beyond middle, running into 12, or 11 absent, being replaced by an anastomosis.

This family agrees with the Limacodidae in the absence of the areole together with the frequent presence of the median vein; it differs in the well-developed tongue (though to this there are exceptions), and in the origin of the first radial of the hindwings from the middle, or beyond the middle of the cell; when this vein disappears it is replaced by an anastomosis in the same position. The resemblance between the neuration of the two families is deceptive, being due to convergence. In many genera of Zygaenidae all the veins of the forewings arise separately from the cell as in the Hesperidae, some Pyraloidea and Pterophoroidea, and many Tineoidea. It can scarcely be doubted that in all these instances the apparently simple neuration has arisen by obsolescence of the chorda leaving an areocel. We may confidently expect that an examination of the pupal tracheation in the Zygaenidae will confirm this. In the Limacodidae we have reason to believe the areole has disappeared by a wholly different process, that of coalescence.

There have been few additions to the small number of Australian species since Meyrick's revision published in 1886; and they fail to give an adequate impression of the family, which is of moderate size, and notable for its variety of structure and appearance. Probably it represents an ancient group which was once much

larger, and has been to a great extent superseded by more modern developments. It is now rather isolated, though more nearly related to the Tineoidea than to any other superfamily, and appears sufficiently distinct to constitute the superfamily Zygaenoidea.

Key to Genera.

1.	Hindwings small, less than ½ length of forewings	*Thyrassia*
	Hindwings moderate or rather large, two-thirds or more in length	2
2.	Forewings with 7 and 8 stalked	3
	Forewings with 7 and 8 not stalked	4
3.	Hindwings with 4 and 6 absent	*Homophylotis*
	Hindwings with all veins present	*Onceropyga*
4.	Hindwings with 6 absent	*Hestiochora*
	Hindwings with 6 present	5
5.	Hindwings with 4 absent	*Pollanisus*
	Hindwings with 4 present	*Neoprocris*

Gen. 1. THYRASSIA Butl.

Journ. Linn. Soc., Zool., 1876, p. 355.

Tongue present. Palpi very short, porrect, slender, smooth, apex pointed. Antennae bipectinate to apex in both sexes. Tibiae without spurs; anterior tibiae with a moderate strigil. Forewings with 2 from two-thirds, 3 from angle, 9 and 10 connate or stalked, 8 approximated, connate, or short-stalked with 9, 10, or 8 and 9 short-stalked and 10 connate, 11 from shortly before upper angle. Hindwings small, less than half length of forewings; cell two-thirds, all veins present and separate, 6 widely separated from 7, costal edge of cell weakly developed or obsolete, 11 represented by a transverse bar between 12 and end of cell.

Type, *T. subcordata* Wlk. from India. There is much variation in veins 8, 9, 10 of forewings. The genus mimics the Syntomidae.

1. THYRASSIA INCONCINNA.

Thyrassia inconcinna Swin., *Cat. Oxf. Mus.*, i, 1892, p. 55.—*Monoschalis mimetica* Turn., *Trans. Roy. Soc. S. Aust.*, 1902, p. 200.

North Queensland: Lizard Island, Cairns, Townsville.

Gen. 2. HOMOPHYLOTIS Turn.

Turn., *Trans. Roy. Soc. S. Aust.*, 1904, p. 243.

Frons smooth, rounded, projecting. Tongue present. Palpi long (about 2), smooth, cylindrical, pointed, porrect. Antennae in ♂ bipectinate, pectinations very long, but not reaching to apex, which is simple; in ♀ simple. Posterior tibiae without middle spurs; terminal spurs moderate; anterior tibiae with strigil as long as tibia. Forewings with 2 from near angle, 7 and 8 stalked, 7 to termen, 11 from two-thirds. Hindwings with 4 absent (coincident with 3), 5 approximated at origin to or connate with 3, 6 absent, 11 from middle of cell connecting it with 12.

The neuration of the hindwings is hard to make out, and wing-folds are easily mistaken for veins, but that given is, I think, correct. Type, *H. thyridota* Turn. Besides this Jordan (*Seitz. Faun. Indo-austral.*, p. 46) enumerates eight other species from the Archipelago and India.

2. HOMOPHYLOTIS THYRIDOTA.

Turn., *Trans. Roy. Soc. S. Aust.*, 1904, p. 243.

North Queensland: Cooktown, Cairns. According to Jordan also from Batchian in the Moluccas.

Gen. 3. ONCEROPYGA Turn.

Trans. Roy. Soc. S. Aust., 1906, p. 136.

Frons smooth, rounded, projecting. Tongue present. Palpi moderately long, very slender, smooth, acute, porrect. Antennae of both sexes bipectinate to apex, pectinations in ♂ very long, in ♀ moderate. Posterior tibiae without middle-spurs, terminal spurs moderate, anterior tibiae without strigil. Abdomen of ♀ with terminal segment much swollen and very shortly rough-haired. Forewings with 2 from seven-eighths, 7 and 8 stalked, 7 to termen, 11 from two-thirds. Hindwings with all veins present, 3 and 4 connate or stalked, 6 and 7 separate, parallel, costal edge of cell weakly developed, 11 from middle of cell running into 12.

Only the single species is at present known.

3. ONCEROPYGA ANELIA.

Turn., *Trans. Roy. Soc. S. Aust.*, 1906, p. 137.

The sexes are similar except in antennae and abdomen.

Queensland: Westwood, Mt. Tambourine, Toowoomba. New South Wales: Bulli.

Gen. 4. HESTIOCHORA Meyr.

PROC. LINN. SOC. N.S.W., 1886, p. 788.

Frons smooth, not projecting. Tongue present. Palpi short, porrected or drooping, pointed, hairy beneath. Antennae in ♂ bipectinate, but simple towards apex; in ♀ simple or serrate. Posterior tibiae without middle-spurs; terminal spurs short; anterior tibiae without strigil. Abdomen of ♀ with terminal segment much swollen and very shortly rough-haired. Forewings with all veins present and separate, 2 from seven-eighths, 11 from three-fourths. Hindwings with 2 from two-thirds, 4 and 5 separate, connate or stalked, 6 absent, 11 absent, 12 anastomosing with cell.

Type, *H. tricolor* Wlk.

1.	Collar red or orange	2
	Collar black	*rufiventris*
2.	Forewings with reddish or orange markings	3
	Forewings without such markings	*tricolor*
3.	Forewings with subapical orange or reddish spot	*erythrota*
	Forewings without subapical spot	*xanthocoma*

4. HESTIOCHORA XANTHOCOMA.

Meyr., PROC. LINN. SOC. N.S.W., 1886, p. 788.

North Australia: Darwin. Queensland: Westwood, Duaringa.

5. HESTIOCHORA ERYTHROTA.

Meyr., PROC. LINN. SOC. N.S.W., 1886, p. 789.

Queensland: Brisbane. New South Wales: Dorrigo, Sydney, Goulburn.

6. HESTIOCHORA TRICOLOR.

Procris tricolor Wlk., *Cat. Brit. Mus.*, i, p. 111.—*Hestiochora tricolor* Meyr., PROC. LINN. SOC. N.S.W., 1886, p. 789.

Queensland: Brisbane, Miles. New South Wales: Sydney, Bulli, Jervis Bay. Victoria: Melbourne, Wandin, Fernshaw, Healesville, Gisborne. Tasmania: Launceston, Deloraine, Hobart, Triabunna. South Australia: Mt. Lofty. Western Australia: Perth, Mt. Dale.

7. Hestiochora rufiventris.

Meyr., Proc. Linn. Soc. N.S.W., 1886, p. 790.

Victoria: Mallee District (National Museum, Melbourne). Western Australia: Albany, Geraldton.

Gen. 5. Pollanisus Wlk.

Cat. Brit. Mus., i, p. 114.

Frons smooth, rounded, more or less projecting. Tongue present. Palpi short or moderate, porrect, slender, smooth, pointed. Antennae of ♂ bipectinate, but usually simple near apex, pectinations moderate, long, or very long; in ♀ stout, simple. Posterior tibiae without middle spurs, terminal spurs short, anterior tibiae without strigil. Forewings with all veins present and separate, or rarely 7 and 8 connate or short-stalked, 2 from not far before angle, 11 from four-fifths. Hindwings with 4 absent, 3 and 5 widely separate, approximated, or connate, 6 and 7 separate, 11 absent, 12 anastomosing with cell from before to beyond middle.

Type, *P. apicalis* Wlk. This, the principal Australian genus, is directly derived from *Neoprocris*. The species require careful discrimination. The ♀ is usually smaller than the ♂ and in one species nearly apterous.

1.	Hindwings elongate, not broader than forewings, thinly scaled towards base	2
	Hindwings not elongate, broader than forewings, uniformly scaled	9
2.	Abdomen with white lateral margins	*leucopleurus*
	Abdomen not so	3
3.	Forewings with pale spots	*trimaculus*
	Forewings not spotted	4
4.	Forewings blackish-fuscous	5
	Forewings brilliant blue-green	*apicalis*
5.	Collar brilliant coppery	6
	Collar wholly or partly blue-green	8
6.	Abdomen brilliant coppery or fuscous	*subdolosus*
	Abdomen brilliant blue-green	7
7.	Thorax, except collar, fuscous	*cyanotus*
	Thorax mixed with brilliant coppery	*empyreus*
8.	Forewings sprinkled with metallic green	*amethystinus*
	Forewings and cilia wholly fuscous	*eumetopus*
9.	Forewings short, apex obtusely rounded, antennae of ♂ pectinate to apex, ♀ nearly apterous	*calliceros*
	Forewings proportionately longer, apex more pointed, antennae of ♂ simple near apex, ♀ with wings fully developed	10
10.	Head and collar brilliant blue-green or coppery, hindwings with 3 and 5 separate	11
	Head and collar dull bluish, hindwings with 3 and 5 connate or nearly so	*coronias*
11.	Thorax wholly brilliant blue-green or coppery	*viridipulverulentus*
	Thorax, except collar, blackish-fuscous	*lithopastus*

8. Pollanisus leucopleurus.

Procris leucopleura Meyr., Proc. Linn. Soc. N.S.W., 1886, p. 792.

Queensland: Brisbane, Stradbroke I., Toowoomba. New South Wales: Gosford, Sydney, National Park.

9. Pollanisus trimaculus.

Procris trimacula Wlk., *Cat. Brit. Mus.*, i, p. 110; Meyr., Proc. Linn. Soc. N.S.W., 1886, p. 792.

New South Wales: Gosford, Sydney, National Park, Bulli.

I think the locality "Richmond River" may be an error.

10. POLLANISUS SUBDOLOSUS.

Procris subdolosa Wlk., *Cat. Brit. Mus.*, xxxi, p. 62; Meyr., PROC. LINN. SOC. N.S.W., 1886, p. 793.

The abdomen varies in colour from brilliant metallic coppery-red to dull fuscous.

North Queensland: Cape York, Cairns, Herberton, Palm Is., Townsville. Qland: Yeppoon, Rockhampton, Eidsvold, Gayndah, Nambour, Caloundra, Brisbane, Stradbroke Is., Mt. Tambourine, Coolangatta, Bunya Mts. (3,000 ft.), Stanthorpe. New South Wales: Lismore, Tenterfield, Glen Innes, Newcastle, Sydney, National Park, Bulli, Wollongong, Jervis Bay. Victoria: Melbourne, Wandin. Tasmania: Launceston, Beaconsfield. Western Australia: Albany.

11. POLLANISUS CYANOTUS.

Procris cyanota Meyr., PROC. LINN. SOC. N.S.W., 1886, p. 793.

New South Wales: Sydney, Bathurst.

12. POLLANISUS EMPYREUS.

Procris empyrea Meyr., PROC. LINN. SOC. N.S.W., 1887, p. 927.

This is slightly larger than *cyanotus*, the thorax wholly or partly brilliant coppery, and there is some coppery irroration on forewings.

Western Australia: Albany, Denmark.

13. POLLANISUS AMETHYSTINUS.

Procris amethystina Meyr., PROC. LINN. SOC. N.S.W., 1887, p. 927.

This is somewhat larger than the following; the forewings are sprinkled with metallic green.

Western Australia: Perth, Mt. Dale, Bunbury.

14. POLLANISUS EUMETOPUS, n. sp.

εὐμετωπος, with beautiful forehead.

♂. 16 mm. Head bright metallic blue; crown partly fuscous. Palpi short and very slender; fuscous. Antennae fuscous; pectinations in ♂ 6, apical one-eighth simple. Thorax fuscous; collar and underside bright metallic blue. Abdomen fuscous; most of dorsum bright metallic blue-green. Legs fuscous. Forewings elongate, costa nearly straight, apex round-pointed, termen slightly rounded, strongly oblique; fuscous; cilia fuscous. Hindwings rather narrow; 3 and 5 separate; fuscous; rather thinly scaled in disc towards base; cilia fuscous. Underside of hindwings partly suffused with bright metallic blue.

North Queensland: Kuranda, near Cairns, in June; one specimen.

15. POLLANISUS APICALIS.

Procris apicalis Wlk., *Cat. Brit. Mus.*, i, 1854, p. 111; Meyr., PROC. LINN. SOC. N.S.W., 1886, p. 794.—*Pollanisus sequens* Wlk., *Cat. Brit. Mus.*, i, p. 115.—*Procris novae-hollandiae* Wlgrn., *Wien. Ent. Mon.*, 1860, p. 39.

North Queensland: Herberton. Queensland: Blackbutt, Stradbroke I., Coolangatta. New South Wales: Lismore, Tabulam, Newcastle, Gosford, Sydney, National Park, Jervis Bay, Mt. Kosciusko (3-3,500 ft.). Victoria: Dimboola. Western Australia: Bunbury.

16. POLLANISUS CALLICEROS Turn.

Proc. Roy. Soc. Tas., 1925, p. 115.

New South Wales: Ebor (4,000 ft.), Barrington Tops (4-5,000 ft.), Moonbar in Monaro District (3-3,500 ft., Helms). Tasmania: Moina (2,000 ft.) on Cradle Mountain Road.

Mr. G. M. Goldfinch sends me a ♂ and what I believe to be a ♀ of this species from Barrington Tops. The latter has simple antennae, broad abdomen with large grey terminal tuft, thorax and legs rather small but normal, wings reduced to very small rudiments.

17. POLLANISUS VIRIDIPULVERULENTUS.

Procris viridipulverulenta Guér., *Mag. Zool.*, 1839, Pl. 11, f. 3; Meyr., PROC. LINN. SOC. N.S.W., 1886, p. 794.—*Pollanisus cupreus* Wlk., *Cat. Brit. Mus.*, i, p. 115; Meyr., *l.c.*, p. 794.

Queensland: Yeppoon, Duaringa, Caloundra, Brisbane, Toowoomba, Warwick, Stanthorpe. New South Wales: Ebor, Newcastle, Sydney, Jervis Bay, Katoomba, Bathurst. Victoria: Melbourne, Geelong, Wandin, Castlemaine, Gisborne, Birchip, Sea Lake. Tasmania: Launceston, Zeehan, Strahan, Cradle Mt. (2-3,000 ft.), Hobart, Tasman Peninsula. South Australia: Adelaide, Port Victor, Port Lincoln. Western Australia: Albany, Busselton, Perth, Waroona, York, Geraldton.

The Eastern Australian form is nearly always brilliant blue, blue-green, or green; the Western Australian (*cupreus*) nearly always purple-coppery, but occasionally green; the South Australian (*adelaidae*) green, or coppery-green, is intermediate. I have also a coppery-green ♂ from Strahan. We may distinguish three local races: to regard them as subspecies would I think, involve us in the absurd position of being unable to determine to what subspecies a specimen belongs, except by reading the locality label.

18. POLLANISUS LITHOPASTUS, n. sp.

λιθόπαστος, jewel-sprinkled.

♂. 18-24 mm. ♀. 18-20 mm. Head fuscous; face shining blue or blue-green. Palpi short, slender; fuscous. Antennae fuscous; pectinations in ♂ 5, apical one-tenth simple. Thorax fuscous; collar and underside shining blue or blue-green. Abdomen fuscous; dorsum partly or wholly shining blue or blue-green. Legs fuscous. Forewings triangular, costa straight to two-thirds, thence gently arched, apex round-pointed, termen only slightly rounded, slightly oblique; fuscous irrorated with a few or many shining blue-green scales; cilia fuscous, apices paler. Hindwings broad; 3 and 5 separate; fuscous; uniformly scaled; cilia fuscous. Underside of hindwings, and sometimes also of forewings, more or less irrorated with shining blue-green scales.

One example from Strahan has the blue-green markings and irroration replaced by coppery-red. Near *viridipulverulentus*, from which it differs in the fuscous crown, thorax and forewings.

New South Wales: Ebor (4,000 ft.) in January, Barrington Tops (4-5,000 ft.) in December. Victoria: Melbourne, Wandin (Beaconsfield) in December, Gisborne in January, Yinnar, near Moe, in December. Tasmania: Cradle Mountain (2,000 ft.) in January, Rosebery, near Zeehan, in February, Strahan in February. Thirteen specimens.

19. POLLANISUS CORONIAS.

Procris coronias Meyr., PROC. LINN. SOC. N.S.W., 1886, p. 792.

This species may be recognized by its comparatively short antennal pectinations, complete absence of brilliant or metallic colouring, and close approximation of 3 and 5 of hindwings.

New South Wales: Glen Innes, Ebor (4,000 ft.), Barrington Tops (4-5,000 ft.), Gosford, Sydney. Victoria: Melbourne, Wandin, Moe, Gisborne, Dunkeld. Tasmania: Zeehan. The locality "Maryborough" may be an error.

Gen. 6. NEOPROCRIS, nov.

Frons smooth, rounded, projecting. Tongue present. Palpi moderate, porrect, smooth, slender, pointed. Antennae in ♂ shortly bipectinate, towards apex simple; of ♀ thickened except near base, simple. Abdomen broadly flattened. Posterior tibiae without middle spurs; terminal spurs short; anterior tibiae without strigil. Forewings with all veins present and separate, 2 from four-fifths, 11 from four-fifths. Hindwings with all veins present, 3 and 4 connate or stalked, 5, 6, 7 separate, parallel, 11 absent, 12 anastomosing at a point with middle of cell.

Type, *N. dolens* Wlk. Nearly allied to the European genus *Procris*. Not having any examples of the latter for examination I cannot be sure of its distinctness, but I infer from Meyrick's British Lepidoptera that in it 11 arises from middle of cell and runs into 12 as in *Zygaena*.

20. NEOPROCRIS DOLENS.

Procris dolens Wlk., *Cat. Brit. Mus.*, i, p. 112; Meyr., PROC. LINN. SOC. N.S.W., 1886, p. 791.

New South Wales: Barrington Tops (4-5,000 ft.). Victoria: Melbourne, Wandin, Gisborne. Tasmania: Cradle Mt. (2-3,000 ft.), Zeehan, Campbelltown, Hobart, Huon River. South Australia: Mt. Lofty.

Index to Zygaenidae.

GENERA.

SPECIES.

(Synonyms in italics.)

AN INVESTIGATION OF THE CAUSE OF AN OYSTER MORTALITY ON THE GEORGE'S RIVER, NEW SOUTH WALES, 1924-5.

By T. C. Roughley, Economic Zoologist, Technological Museum, Sydney.

(Plates xxix-xxxiv; four Text-figures.)

[Read 29th September, 1926.]

Introduction.

The oysters (*Ostrea cucullata* Born.) grown in the George's River, situated a few miles south of Port Jackson, have for a number of years been subject to a mortality during the winter months, and at the request of the State Fisheries, and with the approval of the Department of Education, I undertook an investigation of the mortality expected during the winter of 1924. A further request was made for a continuance of the investigation in the winter of 1925, but pressure of other important work limited my task to the carrying out of one or two experiments intended to verify data obtained during the previous winter.

I had previously studied the types of cultivation used in the George's River (Roughley, 1922), which briefly may be classed under three main headings—(1) stone slabs arranged in pairs like an inverted V between low tide and about three-quarter flood tide level; (2) galvanized wire-netting stretched on wooden frames and supported on posts usually about half tide level; and (3) firm shell beds at the same situation with respect to the tides as the trays. The spat that attaches to the stones is usually allowed to remain there till it develops to maturity, though in some cases when about half-grown it is knocked off and transferred to trays to complete development. The shell beds and trays are stocked with oysters obtained from the bases of the mangroves (*Avicennia officinalis*) and their pneumatophores, from the stones, and also from the cullings when mature oysters are being separated from the immature.

The whole of the cultivation is confined to the foreshores. Although there are areas of firm, level bottom below low tide down to very considerable depths, which were at one time extensively employed for maturing oysters, they are now, and have been for many years, useless for that purpose, on account of the prevalence of the mud worm (*Polydora ciliata*), which invades the shells to such an extent that very few oysters survive to develop to a marketable size (Whitelegge, 1890, p. 41; Roughley, 1925).

My first visit to the river was on July 14, a couple of days being spent in interviews with lessees on different parts of the river in an endeavour to obtain as much information as possible concerning the general features of previous mortalities, and also to choose a site for a temporary laboratory situated conveniently near the water's edge.

I gathered that the mortality has varied in extent during the winters of the past eight or nine years. In some winters the majority of the marketable

oysters has died, and in others only a relatively small percentage, but on no occasion during that period has the mortality been entirely absent. Usually, the larger oysters are the first to die; in fact, in one or two instances the spat has almost entirely escaped.

There being no cultivation below low tide level, the mortality has, of course, been confined to the foreshores, and no indication has been obtained as to whether it would occur amongst oysters that remained submerged during the whole of the winter.

Oysters have died on the southern shores of Botany Bay, at the southern entrance of the river into the Bay, and in every situation up the river to the very limit of oyster life, well beyond Como. The mortality is not equally severe in all places during the same winter; for instance, a lease on the northern shore of Woolooware Bay may lose a very large percentage of oysters, while another on the southern shore may escape with comparatively slight loss. Should the loss be small, it has been found to be usually most pronounced amongst the oysters lowest down, i.e. nearest low tide level. When the mortality has been very heavy, the greatest loss has occurred as a rule low down, but in one or two instances, notably during 1923, those oysters growing on the bases of the mangroves and their pneumatophores, situated well above half tide level, also died in some situations in large quantities. Dead oysters are found in greatest numbers during the months of July, August and September.

The mortality may occur in oysters grown by any of the three methods of cultivation, though there is a general agreement among the lessees that it is usually most severe in those grown on the wire-netting trays. It is possible that the handling received when being transferred to such situations may induce a weakness from which the oysters do not entirely recover. Such a condition has been observed in European oysters. J. H. Orton (1923, p. 23) states, "in relaid oysters an induced physiological weakness due to the conditions during and/or after relaying may show itself in a high mortality rate during the first summer of relaying but also in a still higher rate in the second summer after relaying". No evidence was obtained which would serve to prove or disprove the operation of such a condition in the George's River. It certainly cannot account for the great bulk of the mortality, for amongst the oysters attached to the stones, it is at times almost if not quite as great as on the trays.

Condition of the Oysters.

By the condition or fatness of oysters is meant the state of development of the reproductive organ, the ovary in the female and the testis in the male, *O. cucullata* being dioecious. In the early stages of development of these organs, an oyster is regarded as being in poor condition, but when the ovaries or testes are mature or approaching maturity they become relatively enormously swollen, and in such a state an oyster is spoken of as being fat or in good condition. The lessees were in agreement that for several winters prior to 1924 the oysters in the George's River were exceptionally fat. Now, although it is not altogether rare, it is not usual for oysters in New South Wales to carry the reproductive organ in an advanced stage of development over the winter. Normally, development begins when the temperature rises in the spring, the sexual organs being usually mature by Christmas, when, during the big spring tides which occur at that time, spawning, or the ejection of the eggs or sperms, as the case may be, frequently takes place. After this spawning, development is again rapid, and

a further spawning may take place toward the end of summer. In other cases, development may proceed more slowly and one spawning only may occur, that in late summer; in other cases again the spawning may be an intermittent one extending over several months, and more rarely still it may even continue right throughout the winter, in which case it is probable that it is confined to those oysters growing well below low tide level, where the temperature of the water is not subject to the great variations experienced in shallow water. The normal summer condition is, therefore, that in which the reproductive organ is well developed, and in the winter it is either totally undeveloped or but partially developed. The oyster which carries a fully developed reproductive organ, normal in warm temperatures, through the winter and its accompanying low temperatures, must therefore be considered to be in a state of decided abnormality, and it was thought that this may have been a contributing factor to the mortality. Moreover, the oyster growers are unanimous that not only are the best conditioned oysters the first to die, but that they die in greatest numbers. During the winter of 1924, when the oysters were mostly in very poor condition, the mortality was lighter than for many years, but it was found that in those few situations where the mortality was heavy, the oysters were in poor condition. In the winter of 1925, when the mortality was fairly heavy in most parts of the river, the oysters were again poor. It therefore appears that there is little or no relationship between the mortality and the state of development of the reproductive organ.

The foregoing may be regarded as a summary of the information obtained from the oyster growers, on which reliance can be placed. Much more information was gleaned, but had to be discarded because of lack of unanimity amongst the lessees themselves, and many theories were advanced, some of which appeared to have a reasonable hypothesis and others were obviously untenable.

Having procured this information, the choice of a suitable situation where experimental work could be carried out gave no little trouble. Eventually it was decided to establish headquarters at Shell Point on the southern shore of Woolooware Bay for the reasons that (1) the area of foreshore uncovered there at low tide is a very extensive one, the distance between mean high and low tide marks being 120 yards; (2) on this area all types of cultivation were used extensively; (3) the mortality on these leases had usually been very heavy, particularly so in 1923; and (4) there was a shed close to the water's edge where laboratory work could be carried out.

Mortalities of 1924 and 1925.

During the winter of 1924 there was no general mortality comparable to that of previous winters at Shell Point, where my investigations, records and observations were made. In the bulk of the area under cultivation the number of dead oysters found was so small that it is very doubtful whether the mortality was an abnormal one, for during all times of the year and under any circumstances, an occasional dead oyster may always be found. In two small areas, however, the percentage of dead oysters was considerably in excess of that found elsewhere. On the 30th July, about 100 dead oysters were found on two trays east of Shell Point, and on the following day about an equal number was seen on a shell bed right at the Point. These situations were separated by about 200 yards, and the intervening oysters were all alive. There was one feature in common in both instances; both the trays and the shell bed on which the dead oysters were found were somewhat lower than any others on the leases, and therefore would be

covered with water sooner on the rising tide, and exposed to the air for a shorter period. Although first noticed on July 30, these oysters had died some time previously, the shells being either empty or containing the animals in various stages of putrefaction. Several of the latter when opened were observed to have an accumulation of detritus over and in the vicinity of the palps, and on the inner surfaces of the mantles adjacent to the palps. At the time it was thought that this may have been accounted for by paralysis of the adductor muscle, so that the oyster was unable to snap the shells by contraction of the muscle and eject the material carried forward by the cilia of the gills.

The paralysis of the adductor muscle has since been observed by Spärck (1925, p. 77), who, in a discussion of the death rate of the oysters in the Limfjord, Denmark, states: "It is not the parasitic sufferings, which are, as an essential factor, besides the crabs and perhaps the Asteroids, contributing to the mortality of the oyster, at any rate not in the Limfjord, but another peculiar state of weakness which manifests itself in the oyster not being able to close its shells, the muscle having somehow been paralysed. All sorts of transitions are to be observed from totally normal animals, being able to close their shells quite tight, through some which are only feebly reacting to irritation, as for instance from blows or stabs, to such, which do not react at all, even if they are taken out of the water and a needle stuck into their muscle; the shells cannot even be closed, they at once reopen, if they are pressed together. The animals do not die, even in the last named case they are not dead; if they are pricked in the margin of the mantle it will be seen that it moves, and the animals are not immediately putrefying. Another thing is that these animals, of course, rapidly become a prey to crabs, Asteroids, etc., and that the muscle is gradually atrophied. The suffering is not always due to the same cause, and this paralysis of the muscle seems to be the symptom of different sufferings, exactly as the disappearance of the crystalline style. The paralysis may be brought about by lack of food under high temperature; if in such a case food is supplied, the paralysis ceases, even if it has been present in a rather high degree. Similar observations may be made, if the paralysis occurs at a great refrigeration of the water".

I now think that the accumulation of detritus about the palps of the recently dead oysters found at Shell Point may be due, not to paralysis of the muscle, but rather to the fact that the cilia of the gills and palps continue to vibrate for some hours after the death of the oyster, and automatically carry the food towards the mouth, where it collects and soon forms a mass sufficiently large to cover the palps and portion of the mantle. This was demonstrated later in the investigation, and it is well known, of course, that if small pieces of the gills are cut away and placed in sea water, the cilia continue to function for several hours. Thus the post mortem accumulation of detritus may easily be accounted for by this simple explanation. Moreover, I think it is open to doubt whether a true paralysis takes place in the muscles of the oysters described by Spärck; rather are the symptoms suggestive of a general weakness of the animal, varying in its degree from a slow reaction to external stimuli, to an utter inability to contract the muscle from sheer exhaustion, which may be brought about by such adverse conditions as extremes of temperature or lack of necessary nourishment.

Any comparison of the physiology of *O. edulis* with that of *O. cucullata* must be approached with very great caution for in several important particulars they are very dissimilar. The faculty of gaping and closing of the shells of *O. edulis* when out of water is not possessed by *O. cucullata*. According to Orton (1923,

p. 44), the term "hockler" is given to *O. edulis* "when it gives a hollow sound on being struck a blow. Different terms to express the same meaning are employed in different parts of the country, so that the occurrence of hockley oysters is universal and quite well known. The sound produced when an oyster is sounded is due to the presence of an air gap within the shell valves caused either by loss of the contained liquid or by a slight failure of the shells to close tightly. Oysters will 'hockle' or sound hollow under a variety of conditions and from a variety of causes, such as general physiological or other temporary or permanent weakness, loss of water from an inadvertent opening by even a sound oyster, inability of the shell to close properly when closure has taken place—as, for example, through sudden disturbance during dredging—while grains of sand have been present on the points of occlusion of the shell-valves, and damage to the shell during or after dredging".

The so-called "mud" oyster of southern Australian waters, *O. angasi*, which like *O. edulis* is hermaphrodite, will gape in a day or two after removal from the water, at first slightly, but later as the oyster weakens, the shells will open very widely and will close if the mantle edge is touched with, say, a needle; the closure is at first fairly rapid but later becomes much slower. Even in the latter case the muscle has very considerable power. I once placed a finger between the shells of an oyster that had been out of water for five days and was gaping widely; slowly the shells closed over it and eventually the pain caused by the pressure was so great that the shells had to be hurriedly forced apart with an oyster knife. The muscle in such oysters therefore appears to lack tone rather than strength.

In the case of *O. cucullata* I have never seen a "hockler". If the shells of this species gape, the oyster is invariably found to be dead. The term "hockler", or any other similar term meaning the same thing, is therefore unknown in Australia. If one of these oysters is removed from the water, it will remain closed until it dies, and when once the shells are seen apart it may be taken for granted that the oyster is dead, though it does not invariably happen that when an oyster dies the shells gape; they usually do, but many instances are seen where the shells lie in fairly close apposition after the oyster is dead, and in this position they may persist indefinitely.

On the date when the oysters were obtained with accumulations on the palps, no freshly dead oysters were found, hence an examination of their anatomical and physiological features, beyond that recorded above, and a search for parasites were rendered abortive.

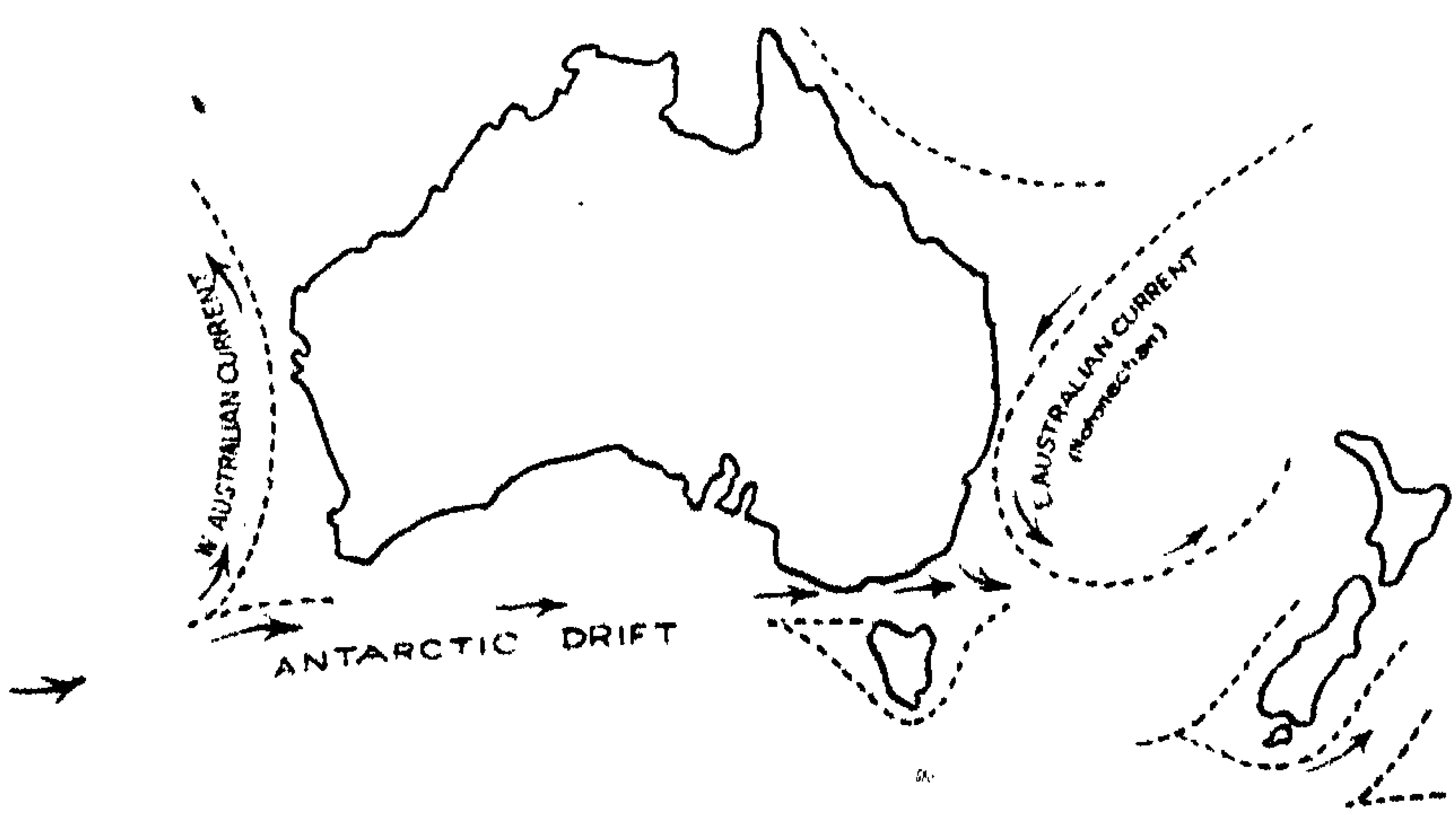
There had previously been a fairly heavy mortality at the head of Woolooware Bay. This occurred among the oysters on trays, also situated low down, but the actual area of the mortality was a small one. The dead oysters were first seen by the lessee on July 20, before many of them had begun to putrefy. I was not informed until July 24, and an inspection then failed to reveal any freshly dead oysters. The gaping shells numbered probably 50% of the oysters on the trays. They had been gathered from the mangroves eight months previously, when about half-grown, and a very rapid growth of shell had taken place after they were laid out on the trays. The majority were now large, marketable oysters, but very poor in condition. No mortality occurred elsewhere at the head of the bay.

Toward the end of August numbers of dead oysters were found on trays at Carter's Island. Owing to pressure of other duties, an inspection was not made of this area, though indications pointed to the fact that death had occurred some time previously, most of the shells being reported to be quite empty.

About the middle of September, after I had returned from the river, it was reported to me that there was a heavy and fairly general mortality up the river, about Como (some five miles from its entrance into Botany Bay). This, on inspection, was found to be quite correct, and an account of the features of this mortality is given later in this paper.

Range of O. cucullata.

The question of the geographical distribution of *O. cucullata*, studied in connection with a seasonal mortality, is an important one, for temperature undoubtedly plays an important part in regulating the area over which the species may thrive. In Australia it has been recorded from King George's Sound at the south-west corner of the continent, though it appears never to have been plentiful there. In a recent communication, the Chief Inspector of Fisheries of Western Australia, Mr. F. Aldrich, informed me that he had never found *O. cucullata* south of the 30th parallel of south latitude. From here it extends over the north-west, north, east and south-east coasts as far south as the Gippsland Lakes in Victoria, where I am informed by Mr. F. Lewis, Chief Inspector of Fisheries of Victoria, it is rare. On the southern coast of Australia west of the Gippsland Lakes it does not occur. The range of this species outside Australian waters extends through the East Indies to India and on the north to Japan; it occurs also at Norfolk Island, New Caledonia and on the north of the North Island of New Zealand. A study of this distribution shows that its northern and southern limits are restricted by the lower temperatures of those



Text-fig. 1. Map showing the prevailing currents on the coasts of Australia.

regions. Explanation of the more extended southern range on the eastern coast of Australia than on the western, may be found in the prevailing currents which wash those shores (see Text-fig. 1). The east coast of Australia is swept by a warm current from the north which has been termed the notonectian, while the current on the west coast is an antarctic drift from the south-west. The south coast of Australia is washed by an easterly sweep of this antarctic drift which meets the notonectian south-east of Australia. The current of the North Island

of New Zealand is a mixture of the notonectian and the antarctic, the former, owing to its lower specific gravity, having a greater influence on the surface temperature than the latter. A certain amount of influence is, however, exerted by the antarctic current, and the water of the North Island of New Zealand is somewhat colder than that of the east coast of Australia at similar latitudes. The result so far as oyster life is concerned is seen in the relative paucity of its occurrence, and probably, too, in the irregularity of the spawning periods of the oysters, for during some summers the oysters do not spawn at all, and there is no doubt that the temperature of the water plays an important part in retarding the development of the reproductive organ.

That the distribution of marine animals is dependent very largely on the prevailing temperature of the water, and in the case of sedentary animals left bare by the tide, on the temperature of the air also, is of course well known. In the southern hemisphere a cold current from the south will extend the range of subantarctic fauna far higher than is possible in the case of a warm current from the north. Examples of this are seen on every coast, one of the most striking being found on the west coast of America. The current of relatively cold water which runs northward along that coast allows many of the southern types of animals to extend far to the north, and carries the characteristically sub-antarctic Isopod genus *Serolis* as far north as the coast of Southern California.

In marked contrast to the distribution of *O. cucullata* is that of *O. angasi*, which is restricted in its range to the colder waters of the continent. This species occurs quite plentifully on the south coast of Australia, and at one time extended as far north on the east coast as the Clarence River. Its numbers decreased as its northerly limit was reached, and during the last century it has gradually disappeared from north to south till now it is extinct north of the Clyde River. From here it gradually increases in numbers as it approaches the Victorian border, and in the Panbula River is still fairly common. It is found also on the coast of Tasmania, and the oyster of the South Island of New Zealand, which reaches its maximum degree of productiveness at Stewart Island, off the extreme south, is generally recognized as a local variety of the species.

If, then, the colder waters of southern Australia are unsuitable for the existence of *O. cucullata*, it is reasonable to presume that the nearer these waters are approached the greater becomes its struggle for existence, and therefore the most critical period in the life of those oysters growing in the region approaching its southernmost limit must of necessity occur during the coldest period of winter. Now, the mortality on the George's River always occurs during July, August and September, which are the coldest months of the year in New South Wales. Moreover, reports have at various times been received of a winter mortality on all the rivers of the southern half of New South Wales, i.e. from the George's River to the Panbula. The Hawkesbury River, situated a little north of Port Jackson, has never known a winter mortality, though Brisbane Water during the winter of 1925 lost considerable numbers in certain situations.

The fact that the mortality is confined to this area, which embraces the extreme southern range of the species, suggests, when taken in conjunction with the season of its occurrence, that low temperature plays a part at least in causing it.

Search has been made through the literature at my disposal for records of mortalities caused by low temperatures in other parts of the world, but beyond general statements of the effect of extremes of temperature mentioned more or

less incidentally, I can find no record of any special investigation into this question. But even if a critical temperature had been accurately established for other species of oysters in other countries, it would not by any means follow that the same temperature would be a critical one for *O. cucullata* on the coast of New South Wales. Each species has its own range of temperatures between which it can live and thrive, and a record of such temperatures in other parts of the world would be useful here for comparison only, and would be quite valueless as a basis for investigation. However, the following extracts will serve to show that very low temperatures have been recognized as fatal to oysters in other parts of the world.

Bashford Dean (1891, p. 385) mentions that in Holland in winter the tiles with attached oysters are removed from between tide levels to enclosures (parks) at the foot of the dykes, where a water depth of about a metre may be retained to guard against the danger of freezing.

Stafford in his papers on the Canadian oysters (*O. elongata* on the Atlantic and *O. lurida* on the Pacific coast) in several instances refers to the harmful effects of low temperatures, particularly on the larvae. Writing of *O. elongata* he states (1913, p. 101): "Cold, frost and ice act quickly upon the younger stages, but the larger spat and adults are not so vulnerable".

Writing on "The Native Oyster of British Columbia" and its environment, Stafford (1915, p. 152) states: "Heat stands only second to sea-water in importance to the oyster. That this is so may be judged from the northerly and southerly distribution, which is confined to torrid and temperate zones, and, in fact, to the shallower and warmer portions of these. Adults could withstand greater cold than that to which they are generally exposed, but they need warmth to develop their eggs and young, as well as for the production of abundant food. Too great a degree of heat or too great a degree of cold (which is but absence of heat) is fatal. Where oysters are living at some depth below the surface, extremes of temperature cannot occur because of the protective influence of the water above them, which does not readily or rapidly change. In very shallow water or when exposed to air the direct action of the sun or of frost can go beyond the usual limits. The effect is observable in early summer, when numbers of oysters on flats succumb to the first warm spells of weather, or in winter when they are caught in frost or ice. More extensive mortality, although not so apparent, results from sudden changes of temperature on larvae or other young stages of oysters".

Stafford further states (1915, p. 157) that "it is not cold, but freezing, which is injurious to oysters", and again (1917, p. 101), "Frost and ice are destructive—the first from the formation of crystals in the soft parts of the spat, rending the tissues, the latter from weight or grinding movements".

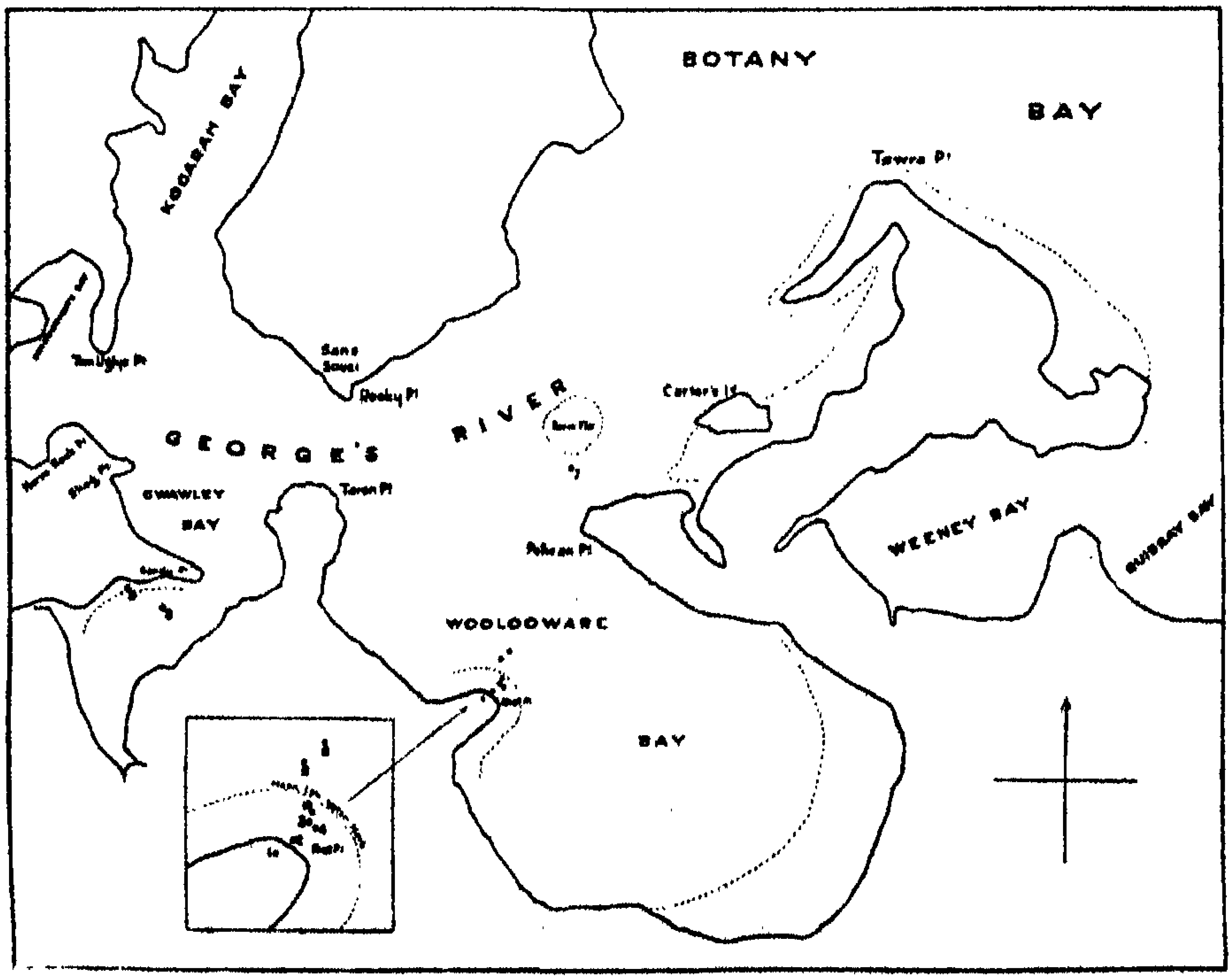
Assuming, then, that low temperatures are responsible for the recurring mortality on the George's River, it is important to determine whether it is that of the air or water, or a combination of both, for knowledge gained in this direction may serve as an indication of remedial measures to be adopted to combat it.

Air and Water Temperatures.

With this object in view, thermometers which register the maximum and minimum temperatures during any given period were securely laid down in various situations, below low tide level, between tide marks, on the grass adjacent

to the beds, and on a post about six feet from the ground. Ten thermometers in all were used. They were placed at the following stations (see Text-fig. 2):

(1) On the grass about 18 yards from mean high water mark at Shell Point.
(2) On a post six feet from the ground at high water mark.
(3) On a wire-netting tray at approximately half tide level, Shell Point.
(4) On a high tray, close to Station 3, four feet six inches above the mud at Shell Point. This tray was submerged for about 1½ hours during an average high tide.
(5) On a tray about six inches below the level of the lowest spring tide, Shell Point.
(6) On a tray about two feet six inches below the level of the lowest spring tide, Shell Point.
(7) On a tray about two feet below the level of the lowest spring tide, Farm Flat.
(8) On a tray about two feet six inches below the level of the lowest spring tide, Gwawley Bay.
(9) On a shell bed about half tide level, Gwawley Bay.
(10) On a shell bed about half tide level, Shell Point.

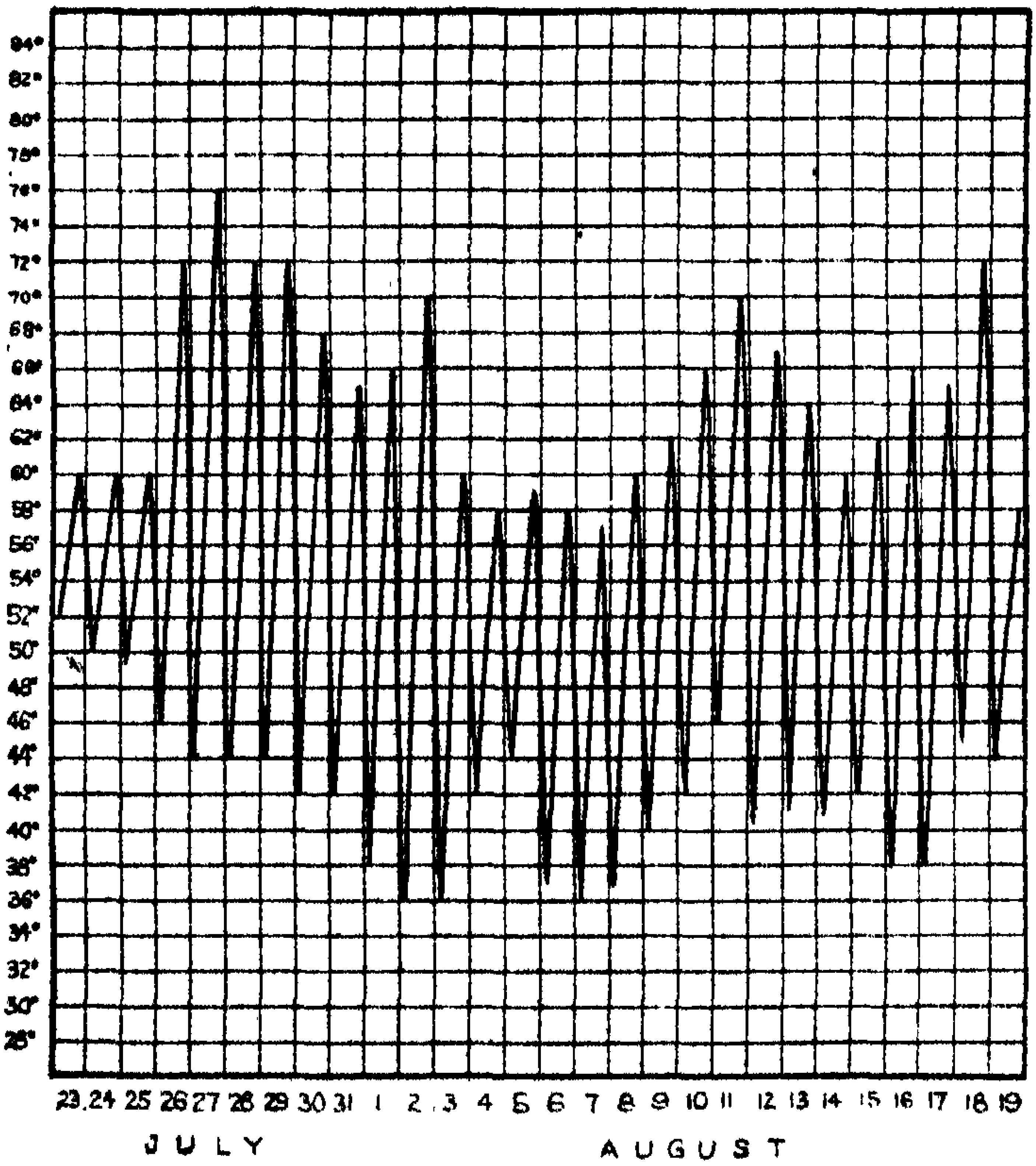


Text-fig. 2. Map of the George's River at its entrance into Botany Bay, showing the stations (1-10) where maximum and minimum temperatures were recorded during the winter of 1924.

The thermometers placed between tide marks were read daily, and those below low tide level almost daily. In the case of the latter, weather conditions

and the distance to be travelled occasionally prevented readings being taken. Fortunately, there was less urgent necessity for daily readings in such situations, for the variation of the temperature was comparatively small.

A comparison of these temperatures (see table, p. 456) on those occasions when all three were read in conjunction shows that the average minimum temperature on the tray at Shell Point (Station 3) was 42·5° F., that of the shell bed at Gwawley Bay (Station 9) was 42·25° F., and that of the shell bed at Shell Point (Station 10) was 43·6° F.



Text-fig. 3. Maximum and minimum temperatures recorded on the foreshore at half tide level at Shell Point (Station 3) during the winter of 1924.

Comparison of the temperatures on the high tray situated just below mean high water level (Station 4) with those on the lower tray at half tide level (Station 3) shows that the average minimum temperature on the high tray was 43·8° F., and that of the low tray 43·2° F., the low tray averaging 0·6° F. lower than that of the high tray.

Reference to the records of minimum temperatures at Stations 5, 6, 7 and 8, where the thermometers were always submerged, will show that not only was the

TEMPERATURE CHART (IN DEGREES FAHRENHEIT).

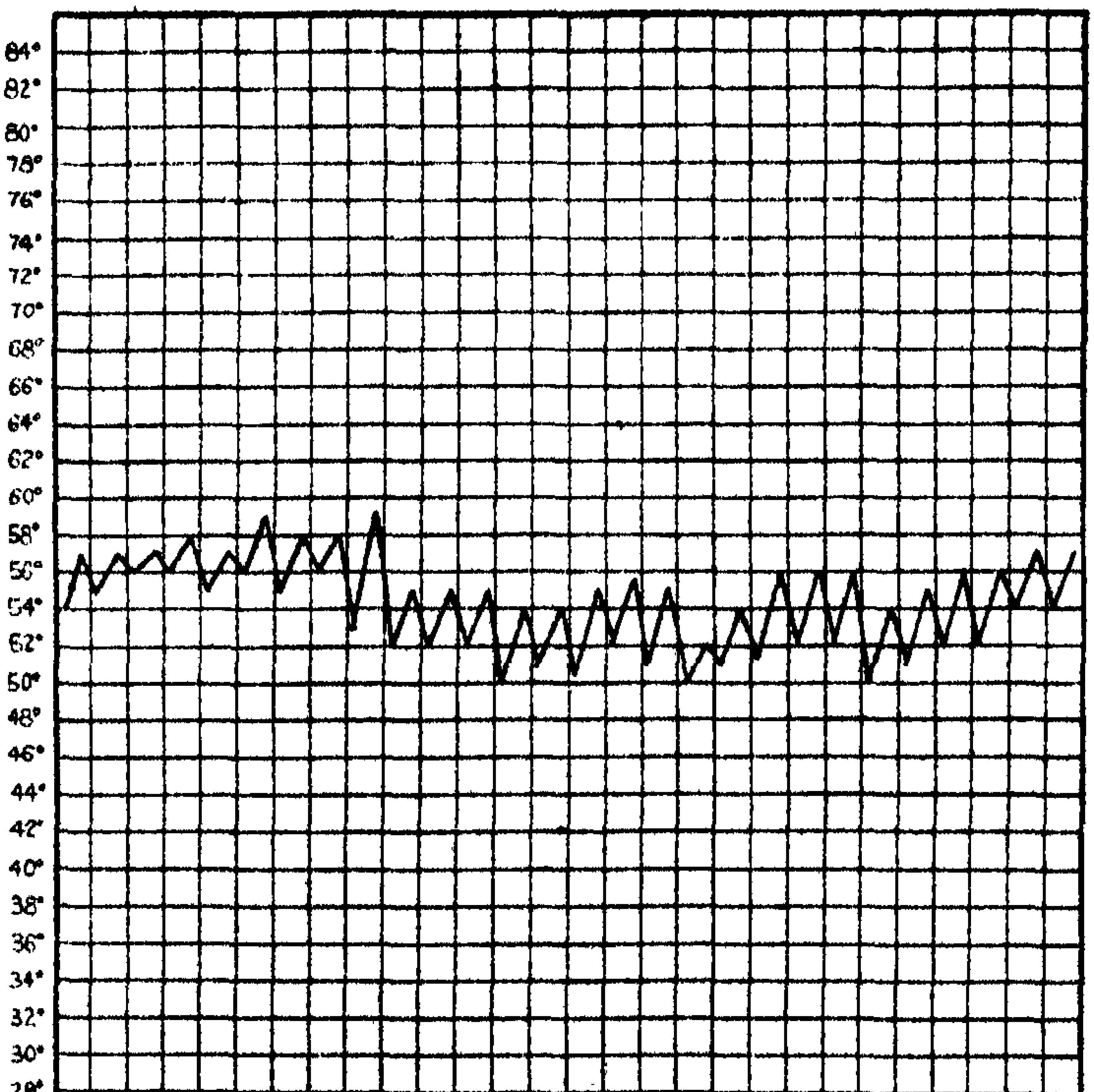
Date.	Station 1 on Grass Shell Point.		Station 2 on Post 6 feet high Shell Point.		Station 3 on Tray Half Tide Level Shell Point.		Station 4 on High Tray Shell Point.		Station 5 6 inches Below Low Tide Level Shell Point.		Station 6 2 ft. 6 in. Below Low Tide Shell Point.	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
July 17	37	82	39		38	67						
July 18	36	82	39		38	68						
July 19	34	82	38	74	36	66	35	70	53	59		
July 20	34	88	38	80	36	64	36	72	53	59		
July 21	34	80	38	76	37		37·5		53	58		
July 22	52	85	52	64	50	56	51		54	58	55	
July 23	50	75	55	65	52	60	52	68	55	58	54	57
July 24	48	72	55	65	50	60	48	66·5	56	59	55	57
July 25	48	68	50	64	49·5	62	40	66	56	58	56	57
July 26	40	87	48·5	63	46	72	42	69	56	59	56	53
July 27	38	87	44	64	44	76	44	70	55	57	55	57
July 28	36	86	44	72	44	72	44	70	55	58	56	59
July 29	38	85	46	72	44	72	48	72	56	59	55	58
July 30	38	76	46	70	42	68	42	73	56	60	56	58
July 31	38	76	46	67	42	65	42	70	53	57	53	59
August 1	34	80	39	68	33	66	37	70	52·5	57·5	52	55
August 2	31	80	42	70	36	70	38	75	53	57	52	55
August 3	32	69	43	64	36	60	38	66	52	57	52	55
August 4	40	68	46	60	42	58	42	60	50	55	50	54
August 5	44	72	48	64	44	59	45	63·5	51·5	54·5	51	54
August 6	34	92	40	66	37	58	37·5	70	51	57	50·5	55
August 7	33	88	40	64	36	57	37	67	52	58	52	55·5
August 8	33	90	40	64	37	60	36·5		52	57	51	55
August 9	36	82	44	62	40	62	44	80	50	54	50	52
August 10	42		46		42	66	44		51	55	51	54
August 11	47	72	51	64	46	70	45	69	52	58·5	51·5	56
August 12	38	70	44	66	40·5	67	44	64·5	52	58	52	56
August 13	36	73	42	67	41	64	41	68	54	57	52	56
August 14	38	63	47	60	41	60	42	61·5	50·5	53	50	54
August 15	40	74	46	64	42	62	42·5	59	51	58	51	55
August 16	35	86	42	66	38	66	38·5	66	51	57	52	56
August 17	35	89	41	68	38	65	38·5	80	51	57	52	56
August 18	42	80	52	70	45	71	45·5	70	54	59	54	57
August 19	44	70	49	66	44	58	48	62	55	60	54	57
August 20	46	76	48	70	46	64	52	68				
August 21	40	84	46	70	42	62	46	77				
August 22	52	85	54	75	51		52					
August 23												
August 24												
August 25	50	84	55	78	53	82	52		55*	63*	56*	62*
August 26	60	77	60	75	59	72	59	74				
August 27	41	92	46	73	44	77	44	77·5				
August 28	46	72	51	69	47	73	48	73				
August 29	52	77	55		52	73	52	77	58*	64*	58*	62*
August 30												
August 31												

* Represents minimum and maximum temperatures reached since last reading recorded.

GEORGE'S RIVER, JULY 17—AUGUST 31, 1924.

Station 7 2 feet Below Low Tide Level Farm Flat.		Station 8 2 ft. 6 in. Below Low Tide Gwawley Bay.		Station 9 on Shell Bed Half Tide Level Gwawley Bay.		Station 10 on Shell Bed Half Tide Level Shell Point.		High Tide.		Wind.
Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	a.m.	p.m.	
								8.48	9.1	Light S.W. to S.E.
		51		40·5				9.37	9.50	Light W. to N.E.
								10.26	10.36	Light W. to Calm.
		51	56					11.16	11.25	Light W.
55·5		51	56	38	66				12.7	V. Light S.W. to S.E. Rain.
55	57	53	55	52·5	60			12.13	1.1	Fresh S.E. to E. Rain.
56	58	53	57	54	67			1.3	1.57	Light S.E. to N.E.
56	58	55	57	53	74			2.0	2.52	Fresh N.W. to Calm. Rain.
57	58	53	58	52	72			2.57	3.47	Light W. to S.
57	58	55	59	50	73			3.58	4.38	Light W. to S.
57	58	54	57			46	77	4.55	5.25	V. Light N.E.
57	58	55	58·5			46	75	5.47	6.9	Light W.
56	58	55	57	44	85	45	74	6.33	6.49	V. Light W. to Calm.
56	58	55·5	57	42	71	44	69	7.16	7.29	W. Fresh to V. Strong.
52	57	52	56·5	40	69	40	67	7.56	8.7	Light W.
51	56	52	55	36·5	69	38	66	8.36	8.46	V. Light W. to E. to S.W.
52	56	51·5	54	37	66	38	68	9.15	9.22	Light W. Very Strong N.W.
		50	55	37·5	70	36	72	9.57	10.2	Strong W.
		48	53	39	57	42	56	10.39	10.43	V. Light S.
51*	54*	50	53	41	67·5	46	56	11.26	11.29	Light S.
		50	53	38	56	39	57		12.18	Calm to V. Light N.E.
		50	53	39	58	39	59	12.23	1.15	Calm to V. Light N.E.
		52	55	38	59	39		1.27	2.18	Calm to V. Light N.E.
		54	56	41	70			2.38	3.24	Calm.
		50	53·5	39	41·5			3.52	4.27	Strong S. Rain.
		50	53	43	58·5	42·5	71	5.0	5.27	Light S. to S.E.
51*	56*	50	53	41·5	71	42·5	67	6.1	6.21	Fresh N.E.
52	56	50·5	56	39·5	68	43	68	6.56	7.12	Light to Fresh W. to S.W.
		50	53	40	70	44	59	7.43	7.58	Strong N.W. to S.W. Gale.
51*	56*	50	55	39	60	41	62	8.29	8.44	Fresh S.
		51	55	40	60	39	64	9.13	9.27	Light S. to S.E.
		51·5	56	37·5	61·5	40	64	9.55	10.9	V. Light W. to V. Light S.
51*	56*	51	55	40	60	46	64·5	10.39	10.50	Variable S. Light.
		53	56·5	40	62		58	11.22	11.32	Light to Mod. N.W.
		53·5	56·5	42·5	66·5		64		12.10	Light S.
		54	59·5	40	66·5		60	12.18	1.0	Light and Var. W.
		56	59	51·5	70	52·5		1.12	1.56	V. Light W. to N.W.
		56	59	51	70			2.14	2.57	Moderate E.
		56	59	50	70			2.23	3.55	Light N.E.
55*	62*	58	62	48	60	54	84	4.30	4.52	Fresh N.E.
		55	61·5	60	80	60	75	5.25	5.42	Strong N.W.
				50	80	47	75	6.13	6.26	Light to Mod. W. to N.E.
				52	70	49	70	6.54	7.6	Mod. S.E.
					76	53	76	7.34	7.45	Light E.
					70			8.12	8.22	Light N.E.
					70			8.51	9.0	Light N.W.

minimum temperature very much higher than that between tides, but the range between minimum and maximum was also confined within far narrower limits. A comparison of the temperatures at these four stations will show that at Station 5 the lowest temperature reached was 50° F., and the highest 60° F.; at Station 6 the lowest was 50° F., and the highest 62° F.; at Station 7 the lowest was 51° F., and the highest 62° F.; and at Station 8 the lowest was 48° F., and the highest 62° F. Omitting Station 7 on account of the relatively fewer number of readings taken, and comparing the minimum temperatures of Stations 5, 6 and 8 on those occasions when the three were read conjointly, we find that the average minimum temperature at Station 5 was 53·1° F.; at Station 6, 53° F.; and at Station 8, 51·8° F. At Station 5 a temperature of 50° F. was reached on two occasions only, at Station 6 on three occasions, and at Station 8 on eight occasions, in addition to which was one reading of 48° F.



Text-fig. 4. Maximum and minimum (water) temperatures recorded two feet six inches below mean low water level (Station 6) at Shell Point during the winter of 1924.

Further consideration will be given to these data when certain theories concerning the possible influence of low temperatures on the vitality of the oysters are discussed.

Cold Water and/or Air Considered as Possible Causes of Mortality.

If the cold weather were the cause of the mortality, it was thought that it might account for it in one or more of the following ways:

(1) Frost lying direct on the oysters, causing the water inside the oysters to freeze, and possibly parts of the tissues also.

This, as we have seen, has been recognized as a cause of death in Europe and North America, and in Europe the precaution is taken to guard against it by transferring the oysters to deeper water during the winter months.

(2) The water, rising over the mud flats, after a big ebb tide during the early hours of the morning when the temperature is lowest, by circulating over the body of the oyster when it opens to breathe and feed, might cause a shock sufficient to lower its vitality, and when repeated, cause its death.

(3) The exposure of the oysters, during a big ebb tide in the early morning, to a low air temperature not necessarily down to freezing point.

(4) A general lowering of the temperature during the winter months, combined with a big range of temperature from the lowest during the night to the highest during the day.

(1) Frost considered as a possible cause of mortality.—Practically everywhere on the George's River the lessees attribute the mortality to frost, though I have not met one who has seen a frost on the beds. Frosts were noticed on the grass flats inshore from the leases on four occasions after July 17, namely July 19, 20, 21 and August 2, the lowest temperature recorded by the thermometer lying on the grass close to the water's edge being 31° F. on August 2. At no time, however, during the investigation from July 17 till August 31 was the temperature on the beds between tide marks nearly low enough to cause a frost. Reference to the temperature chart will show that the lowest temperature recorded at any station was 36° F., which is approximately 7° above the freezing point of the salt water of the average salinity (1·022) where the records were taken. It may be definitely stated, therefore, that those oysters that died at Shell Point, Carter's Island and the head of Woolooware Bay were not killed by frost after July 19.

Temperatures were not recorded in the vicinity of Como and in the Woronora River, where, towards the end of August, a heavy mortality occurred, but it is improbable that lower temperatures would be reached there than at the mouth of the River where the observations were made, for the oyster beds are sheltered from cold winds by high hills. One may reasonably expect a somewhat lower temperature in the vicinity of the flat, open country at the mouth of the river than in such sheltered situations as are to be found in the higher reaches.

Further, it has been found that amongst the oysters on the stones the mortality is as great on the under surfaces, where frost could not possibly lie, as on the upper surfaces. This of itself must preclude the direct action of frost as a possible cause of mortality. Then, too, oysters were found to be dead in large numbers on a vertical concrete wall in the Woronora River, and on the roof of a cave exposed at low tide; here they were sheltered from both wind and frost.

(2) The low temperature of the water rising over mud flats considered as a possible cause of mortality.—When the tide is low and the flats are exposed to a low atmospheric temperature, the temperature of the surface mud and of the water left in puddles, along with the direct action of the cold air itself, has a marked effect in lowering the temperature of the water as it slowly advances on the flood tide. It is well known, of course, that with a low air temperature

the shallower the water the lower its temperature becomes, but in order to determine the extent of this chilling influence, several tests were made, and two examples are here given. The night preceding August 1 was a very cold one, with the tide low at 2.15 a.m. Temperatures taken at 6.30 a.m. showed that at its edge the water varied from 41° F. to 44° F.; at a depth of three inches it was 46° F., and at a depth of five inches 51° F., a rise of from seven to ten degrees in an increase of depth of five inches. Again, on August 3 at 9.30 a.m. the temperature of the water at its edge was 47° F.; a thermometer held beneath the surface as a boat was rowed out to a depth of five or six feet, where the temperature was 53° F., showed a gradual but not a constant rise, for as colder currents were encountered the mercury would drop back a degree or two.

It has been contended that on a very cold night, when the tide is out and the air temperature is at its lowest, the water remaining in pools on the flats freezes, and as it is dissolved by the water of the incoming tide, lowers the temperature of this water till it also approaches freezing point. This certainly did not happen during the winter of 1924. On August 1, when there was frost on the grass inshore, and when the thermometers on the beds between tide marks showed that the lowest temperature reached was 36·5° F., only half a degree higher than the lowest reached during the whole of the winter, the lowest temperature found in any such pool was 41° F., at 5.15 a.m. This is approximately 12° higher than the freezing point of the water.

There is abundant evidence that the mortality of the oysters on the trays during previous years at and slightly below half tide level has always been greater than that of the oysters attached to the bases of the mangroves and their pneumatophores situated nearer high tide level; in fact, the mangrove oysters frequently escaped altogether. The trays are placed on an average about a foot from the bottom; therefore, when, as the tide rises, the water reaches the oysters lying on them, it is already a foot deep. In the case of the mangrove oysters, however, the water circulates over them when only a few inches deep. It has been shown that this shallow water is considerably colder than that circulating over the trays, and if the coldness of the water were the cause of death it is but reasonable to expect that the mangrove oysters would not only be the first to be affected but that they would die in greatest numbers. Moreover, the water creeps gradually over the shell beds and most of the oysters are submerged when the water is only a couple of inches deep; obviously, then, the temperature of this water will be lower than that covering the oysters on the trays, yet the mortality on these beds is not greater than that on the trays, rather is it usually lighter. Clearly, therefore, the vertical distribution of the mortality must preclude the theory that cold water causes a shock or a succession of shocks sufficient to kill the oysters.

It has been presumed, of course, that the oysters open in very cold water and that it circulates over them, but it was consistently found that the oysters will not open their shells when the water is very cold. Much time was spent in an endeavour to determine the lowest temperature at which oysters will open their shells. Observations were made by carefully pressing a solid glass tube against the right shell; if any movement was seen it was concluded that the shells were sufficiently apart to allow ingress and egress of water. In most cases when the right valve of a feeding oyster is prodded, the waste food matter diverted by the palps and accumulated on the mantle edge is forcibly ejected by the sudden closure, and this when seen serves as a further and very reliable indication that the cilia of the gills and labial palps were functioning.

The records of twelve such observations are shown in the following table:

Date.	Time.	Tide.	Situation, Shell Point.	Temp. of water in degrees Fah.	Salinity.	Number of oysters open.
August 1	6.30 a.m.	⅓ flood.	Stones.	45°-47°	1·0225	No oysters open.
,, 2	7.30 a.m.	⅔ flood.	Trays.	50°	1·0225	No oysters open.
,, 2	5 p.m.	Nearly half flood.	Trays.	57°-58°	1·022	Approx. 50% open slightly.
,, 4	10.15 a.m.	Nearly high tide.	High tray 6″ under surface.	52°	1·022	Approx. 30% open.
,, 6	9.30 a.m.	Half flood.	Stones.	51°	1·022	Approx. 10% open.
,, 7	10.30 a.m.	¾ flood.	Stones.	55°-56°	1·022	Majority open.
,, 11	2 p.m.	Half flood.	Stones.	63°	1·022	Majority open widely.
,, 17	8 a.m.	Nearly high tide.	Trays and shell beds.	52°-52·5°	1·021	No oysters open.
,, 18	8.30 p.m.	⅔ flood.	Stones.	59°	1·022	Majority open widely.
,, 25	2 p.m.	¼ flood.	Stones.	68°	1·021	Majority open widely.
,, 27	7 a.m.	One hour on ebb.	Stones.	56°	1·022	Majority open.
,, 27	3 p.m.	Half flood.	Stones.	66°	1·022	Majority open widely.

It will be seen on reference to this table that no oysters were found open at a water temperature of or below 50° F. After one or two observations had failed to show any oysters open at or below this temperature, every available opportunity was taken to determine whether this record was a constant one. Early every morning when the tide was suitable (and in most states of the tide observations were possible on the oysters attached to the stones) from twenty minutes to half an hour was spent in checking this result, but in not a single instance was an oyster found with its shells even slightly open at a temperature of 50° F. or below it. Further evidence is thereby afforded that the oysters do not receive a chill from the cold water, for the simple reason that they do not open to breathe it.

In this respect *O. cucullata* differs considerably from the oyster of the Atlantic Coast of America (*O. elongata*). By means of recording apparatus

continuous kymograph records of all shell movements of oysters for over two months were obtained by T. C. Nelson (1923, p. 91), who found that "Between 4°-6° C. [39°-43° F.] there is a sharp decrease in the ciliary activity of oysters. Normal feeding occurs above this range, while no food is taken when the temperature of the water is below 4° C.". Though kymograph records eliminate possibility of error, nevertheless, my records based on direct observations, made with very great care over a period of upwards of a month, gave such constantly uniform results, that I think they may without reservation be accepted as correct.

Such marked divergence between the two species may perhaps be explained by a comparison of their distribution. *O. elongata* lives, thrives and reproduces as far north as the Bay of Chaleur (on the east coast of Canada) latitude 48° N., and extends south to the Gulf of Mexico; *O. cucullata*, on the other hand, extends from tropical and subtropical regions on the north as far south only as the 38° S. A distribution of *O. cucullata* on the south in latitudes similar to those of *O. elongata* on the north would restrict its northerly range to a little north of Brisbane, and extend it southwards below Stewart Island, south of New Zealand. From this it will be seen that *O. elongata* ranges much farther into the waters of low temperature than does *O. cucullata*. The temperature most suitable for its economy may therefore be a lower one, and this may account for the differences of temperature below which the two species will not feed.

Tests were made to determine the difference in temperature of the body of oysters when exposed to the air and when covered with water. For instance, at 5.45 a.m. on August 1, when the water had just covered the lowest oysters on the trays at Shell Point, six oysters that were still exposed to the air were opened and a thermometer thrust inside the body. The temperatures recorded were: 42° F., 42° F., 42° F., 42° F., 42·5° F., and 42° F., while the temperatures of the oysters removed from the water were: 44° F., 45° F., 45° F., 45·5° F., 46° F., and 45° F. The temperature of the air was 41° F., and of the water 50·5° F. to 51° F. These oysters had been watched carefully, and were prodded now and again with a glass rod in order to determine whether they showed any signs of opening, but in every instance their shells were tightly closed. Actually, therefore, if an oyster should open in the water on a very cold morning, the water circulating over it, being of higher temperature than its body, would tend to warm rather than chill it.

It is considered probable that the reason that the oyster does not open to breathe and feed at low temperatures, is because its vitality is lowered at those temperatures, and a higher temperature is awaited when its organs are functioning normally and its ciliary mechanism is stimulated into greater activity.

A striking example of a lowering of vitality due to low temperature was seen during the course of this investigation. An oyster was opened on August 12 and was placed in a jar containing 20 ounces of sea water; this was changed daily and the oyster lived for eighteen days afterwards. Matter in suspension in the water was carried forward energetically along the edges of the gills, and, as far as could be detected, the whole of it was rejected by the palps; at no time during the eighteen days were any faeces seen in the rectum. The heart beat strongly at all but low temperatures, in spite of the fact that the membrane covering the pericardium was completely torn away when the left shell was removed. On August 27 at 7 a.m., when the temperature of the water surrounding the oyster was 51° F., the beats of the heart were weak and very slow, and as the temperature rose, became stronger and faster. Again, on August 28, at 7.30 a.m., with the temperature of the water 50° F., the heart appeared to have completely collapsed

and had ceased to pulsate. The jar was then placed in the sun, and when the temperature of the water had risen to 51·5° F., the pulsations were fairly strong but slow, the contractions being at the rate of 6 to the minute. The right auricle was expanding and contracting, but the left auricle was apparently not functioning. At 8.10 a.m. the temperature of the water was 52·5° F., and both auricles and the ventricle appeared to be functioning normally, the pulsations being quite vigorous. At 8·45 a.m. the heart beats were strong at the rate of 10 to the minute at a water temperature of 53·5° F. Thus is afforded a striking example of impaired vitality due to the influence of cold. It may be contended, no doubt, that this oyster was under extremely abnormal conditions, having had one shell removed and the adductor muscle severed, and being confined to a small volume of water. But these abnormal conditions were constant at all temperatures, and it was only at the low temperature of 50° F. that the heart failed to function normally. It quickly recovered its poise when the temperature rose. It cannot be deduced, of course, that oysters growing naturally will behave similarly; for instance, it would be idle to infer that the heart of an oyster in nature would cease to function at a temperature of 50° F., but when taken in conjunction with the fact that no oysters were found open at that temperature even on the early flood tide when they were hungry, having been without food since the previous ebb tide, and considered in the light of Nelson's observation that ciliary activity decreases at low temperatures, I think that it may be accepted that the efficiency of the heart is greatly reduced at low temperatures, and probably, too, every physiological function performed by the various organs of the oyster.

That the heart continues to beat at temperatures below 50° F. was repeatedly seen in other oysters opened, but the pulsations were very slow and lacked vigour at the lower temperatures. The following table shows the rate of pulsation of the hearts of two year old oysters at temperatures ranging from 46° F. to 80° F.; in all the oysters examined the left shell was removed by cutting the adductor muscle at its base of attachment, the oyster then lying on its right (flat) shell. A number of observations was made with different oysters at each temperature, and slight variations were found in individual specimens. The figures given in the table represent in each instance the average of a number of counts. While in every oyster the rate of pulsation increases as the temperature rises, the increase is not uniform for oysters of all ages, the pulsations of the hearts of younger oysters being more rapid than those of older ones.

Temperature. Degrees F.	Pulsations per minute.	Temperature Degrees F.	Pulsations per minute.	Temperature. Degrees F.	Pulsations per minute.
46	4·5	55	10	67	18
47	5	57	11	70	20
48	6·5	60	13	75	32
51	8	62	15	80	42
53	9	64	16		

It should be emphasized that in every case these oysters had a shell removed and had no doubt suffered a violent shock by the severance of the adductor muscle. The effect of this is noticed if the pulsations of the heart are watched immediately afterwards; for some time the pulsations are frequently spasmodic, and in some instances I have failed to find any movement whatever in the heart of a freshly opened oyster, but usually in a few minutes the pulsations become quite vigorous and soon resume a normal regularity. So closely does the rate of heart-beat correspond in different oysters of the same age at the same temperature that it is very doubtful whether it varies at all from that of an oyster whose shells are undisturbed.

It would be interesting to determine just how long an oyster would live with one shell removed, when placed on a bed where conditions of aeration, etc. are quite normal. The fact that an oyster lived for eighteen days in 20 ounces of water changed daily points to the assumption that under more natural conditions, protected of course from the heat of the sun and the attacks of enemies such as fish and crabs, an oyster would live for a much longer period. Orton (1923, p. 60) records that "on Jan. 6/21, an oyster was opened at Whitstable for observation of heart beat and left on the bench in the oyster store, that is, with one shell removed by severing the adductor muscle; on a return visit to the store on Jan. 18th the oyster was still alive and the heart and cilia still working—the former feebly—although it had had only one change of water in the interval".

During my investigation on the George's River I observed another instance of such longevity, rendered more interesting because of the very adverse conditions under which the oyster lived. An oyster opened on July 24 was placed in a beaker holding 20 ounces of sea water which was not changed until July 28, after which it was changed daily; in this case the pericardium was intact. On July 29 at 3.30 p.m. the water had a pronounced odour of putrefaction although it had been changed at 9 o'clock the same morning, but the heart was beating quite vigorously. An examination to find the cause of the odour revealed that the muscle was necrosed and putrefying, and on July 31 had completely rotted away. Although the posterior wall of the pericardium formed by the anterior surface of the muscle had now completely gone, and in spite of the fouling of the water caused by the putrefaction of the muscle extending over several days, the heart continued to function vigorously until August 4, when its pulsations became much more feeble, and on the 5th they ceased altogether, eleven days after the oyster was opened. By this time the mantle and gills had also begun to disintegrate. This observation serves to show, I think, that the oyster's tenacity is very much greater than has previously been realized.

Diapedesis (bleeding).

Diapedesis, or the extrusion of blood cells, was frequently observed by Orton (1923, p. 59) when investigating the cause of a mortality of English oysters. It was noticed on two occasions during the investigation on the George's River, in both instances in the oyster which was kept alive with one shell removed for eighteen days. The first case of diapedesis occurred six days after the removal of the shell, and followed closely on the renewal of the water in the jar in which the oyster lay. The oyster was lifted carefully from the jar while the water was changed; the temperature of the stale water was 53° F., and that of the fresh 54° F. A few seconds after the oyster was placed in the fresh water, a thin cloud-like exudation was seen to issue from a position at or very close to the base

of the left auricle, and to continue for about 5-6 seconds. The water was not sufficiently clear to determine whether the point of exudation was actually at the base of the auricle or whether it was inferior to it. After removal by means of a pipette, microscopic examination showed that the exudation consisted of typical granular vacuolated blood cells (leucocytes). It was at once thought that the auricle had been ruptured. This opinion was strengthened by the fact that the pulsations of the heart were very feeble and slow for about two hours afterwards. They then gradually began to increase in strength, and at the end of four hours were as strong as ever. The temperature of the water in the meantime had risen from 54° F. to 60° F. It was now thought that the rupture of the auricle must have been impossible, otherwise the leakage of blood must have continued and caused the oyster's death.

This was confirmed on the following day, for, when the water was changed, the exudation of blood cells again occurred, though in a much smaller quantity than previously. On the first occasion an enormous number of blood cells was lost. On this second occasion the temperature of the stale water was 59° F., and the salinity 1·022. The fresh water was of the same temperature and salinity, and great care was taken not to jar the oyster when laying it in the vessel. Owing to a large amount of sediment in the water, the exact point of extrusion could again not be determined. As on the previous day the pulsations at once became very weak, but in a few hours were normal. The oyster lived for eleven days afterwards, but diapedesis was not again noticed.

It would have been extremely interesting to experiment with other oysters in an endeavour to determine the causes and effect of such bleeding, but its value as a possible source of enlightenment upon the mortality which was being investigated, was considered to be remote, and therefore further research had to be abandoned for work of more immediate necessity. The phenomena are described here purely for their scientific interest.

(3) The exposure of the oysters during a big ebb tide in the early morning to a low air temperature not necessarily down to freezing point.—It has been shown that when the air is at its coldest the temperature of the water is always higher; therefore if low temperatures are the direct cause of the mortality, the air would appear to exert a greater influence than the water. The evidence against cold air as a possible cause of the mortality is, however, very definite. In the first place, if it were the cause it is reasonable to assume that those oysters that are exposed to it longest would die in greatest abundance; therefore, one would expect a greater mortality among those attached to the mangroves near high tide level. Then again, the oysters placed on the high tray (Station 4) were exposed to the air for considerably longer periods daily than those on the trays and beds where cultivation is carried out normally, for they were submerged for about an hour and a half only at an average high tide, and sometimes, when the tide was poor, were not reached by the water at all—yet not a single oyster died there. The average minimum temperature reached on the trays at half tide level was, as we have seen, 0·6° lower than that of the high tray. This variation may be considered as negligible; at any rate it is more than compensated for by the much longer exposure to low temperatures experienced on the high tray. In view of the fact that the mortality at Shell Point (except in two small areas) was probably not an abnormal one, it is unsafe to draw definite conclusions from this experiment in the winter of 1924. For this reason it was repeated in the following winter, when the mortality on the beds about half tide

level was fairly heavy; in this case two trays were placed in widely separated areas, each at the same height with respect to the tide as those used in the previous winter. Again no oysters died.

In an endeavour to account for the greater mortality nearer low than high tide level, it was thought that an explanation might be found in the fact that the shells of oysters grown in the former situations where conditions were more conducive to rapid growth, might be thinner and therefore afford the animal less protection against cold, than those grown under the adverse conditions which obtained nearer high tide level. There is no doubt that oysters grown low down usually possess a softer shell than the more slowly grown, crumpled shell of the mangrove oysters. In order to test the relative conductivity of the shells, the following experiment was carried out. On August 7, at 3 p.m., mangrove oysters growing above three-quarter tide level, and tray oysters growing at about one-third average flood tide level, were laid in water close together until it was found by opening several of each that the temperatures of their meats were the same, i.e. 58° F. They were then packed quickly in broken ice in pairs and allowed to remain for five minutes, when they were removed and opened, and a thermometer thrust into their meats. A comparison of the resulting temperatures is shown in the following table:

No.	Mangrove Oysters. Degrees F.	Tray Oysters. Degrees F.
1	41	43
2	44	41
3	45	45
4	42	45
5	42	40
6	47	44
7	43	42
8	43	43

It will be seen that in four instances the temperatures of the mangrove oysters did not go as low as those from the tray; in two instances they were the same; and in two, the temperature was lower. The mangrove oysters averaged 43·4° F. and the tray oysters 42·9° F., a difference of 0·5°, which for all practical purposes may be considered as negligible. It is obvious, therefore, that the shell of the mangrove oyster conducts cold as readily as that of the tray oyster. Another interesting fact revealed by this experiment was the rapidity with which external temperatures are conducted through the shells and the body of the oyster when the shells are closed. A drop of 15°, from 58° F. to 43° F. in five minutes, when surrounded by an external temperature of 32° F. was quite unexpected. The shell obviously affords little protection against changes of temperature.

(4) A general lowering of the temperature during the winter months combined with a big range from the lowest during the night to the highest during the day.—A direct determination of this question must, of necessity, require a record of maximum and minimum temperatures during both summer and winter over a number of years. Indirectly, however, very conclusive evidence was obtained which must eliminate this theory as a possible cause of the mortality, mainly

as the result of the records of temperatures obtained on the trays placed in different situations below low tide. These trays, as we have seen, were placed in July at Stations 5 and 6, Shell Point; 7, Farm Flat; 8, Gwawley Bay (see map, p. 454), and were covered with oysters to the same extent as those used in the ordinary course of cultivation; they were supported about a foot above the bottom by a rectangular frame. After being submerged for approximately three months, the mortality of oysters on each tray was found to be severe, as the following table shows:

Station.	Laid down.	Taken up.	Total oysters on tray.	Number dead.	Percentage of dead oysters.
5 (Shell Point) ..	July 18	October 29	305	134	44%
6 (Shell Point) ..	July 21	October 29	278	114	41%
8 (Gwawley Bay) ..	July 17	October 28	439	91	20%

The lowest temperature reached on any of these trays was 48° F. (with one exception 50° F. was the lowest temperature reached), and the highest up to August 29, when regular readings ceased, was 63° F. It has already been shown that the temperature at Station 8 was fairly consistently lower than those at Stations 5 and 6, the temperature of 50° F. being reached there on eight occasions as against three at Station 6 and two at Station 5. Small though the difference is, if low temperatures were the cause of the mortality one would expect to find more oysters dead at Station 8 than at Station 5. Reference to the table will show that the reverse is the case, the percentage being 20 as against 44. Although I was unable to examine the trays at Farm Flat, where a large number stocked with many thousands of oysters were laid on poles to keep them from direct contact with the bottom, the lessee raised a number in October, 1924, and reported a loss of from 40-50%.

When the trays were examined at Shell Point and Gwawley Bay, it was found that the oysters had been dead for some time, and there was no evidence to show the cause of death. The oysters that were still alive appeared to be quite healthy, and in as good condition, if not slightly better on the average, as when they were laid down. In two or three instances only were slight worm infestations of the shell seen. These had been well chambered off and were probably there before the oysters were placed below low tide level.

If the mortality of these oysters was caused by the same agency as of those between tide marks during previous winters, definite proof is provided that very low temperatures and a big range of temperatures were not the cause, for, whereas those oysters situated between tide marks are frequently subjected to temperatures of 36°, 37° and 38° F., with a range up to 70° F. and beyond, those which are always covered with water do not reach below a temperature of 48° F. with a range to a maximum of 64° F.

Some doubt was felt that the mortality below low tide may have had a different origin from that on the foreshores, and may possibly have not been peculiar to the winter months. If it could be demonstrated that no mortality occurs amongst oysters submerged during the summer months but regularly occurs at the same period as that between tides, then the assumption is fairly warranted

that both originate from the same cause. In order to determine this, I had a tray, stocked with oysters, placed at Station 6 in December, 1924. These oysters were left there for the same length of time as those used for the winter experiments, and when raised in March, 1925, only two oysters were found to be dead, the remainder being in better condition than beforehand; actually they thrived better than those growing on the foreshores during the same period. Again, during the following winter (1925) oysters were placed on two trays at Stations 5 and 6 for three months, from June to September, and when raised it was found that 34% of the total was dead on the tray at Station 5, and 48% at Station 6—a very much greater percentage than was found between tide levels during the same period. I think that these experiments have been conducted over a sufficient period to justify the statement that the mortality on the George's River is greatest where the oysters are in the water for the longest time.

Review of Low Temperatures Considered as the Direct Cause of the Mortality.

In the light of the experiments and observations described in the foregoing pages, I submit that it may be safely deduced that low temperatures do not directly cause the mortality on the George's River, for is it not reasonable to presume that, if it were so, those oysters that are exposed to the lowest temperatures longest would die in greatest numbers? Having in mind the distribution of the species, and the occurrence of the mortality during the coldest months of the year, I certainly expected that those oysters which were placed on the high tray, exposed as they were to low temperatures for considerably longer periods than those at half tide level, would die more abundantly, while those which were covered with water where the range of temperature was comparatively small, would completely survive, or at least would suffer a mortality very much less severe than the oysters exposed to the air. In the two winters that these experiments were carried out, actually the reverse occurred. This result was quite unexpected, though a certain amount of suspicion was raised against the direct action of low temperatures by the evidence gathered from the lessees that usually those oysters situated nearest low tide level died more plentifully than those growing higher up. Then, too, the fact that the older oysters died in greater numbers than the younger spat is contrary to what might be expected when it is considered that the older oysters have survived more or less similar conditions, and therefore should be acclimatized and rendered more resistant to a repetition of them. Moreover, there is abundant proof that the youngest oysters, i.e. the larvae and young spat, are more quickly and seriously affected by extremes of temperature than older ones.

Evidence of this is seen in a report furnished by the Inspector of Fisheries on the Clyde River, New South Wales, where, after very hot weather during February, 1926, considerable quantities of oysters died. On receipt of his report from the State Fisheries, I asked that careful inspection be made to determine, if possible, such features of the mortality as its relation to tide levels, the aspect of the beds, and the sizes of the oysters most affected; and also whether in its distribution it resembled that which occurs during the winter. On these questions the inspector replied as follows:

"1. The mortality is confined to the space between tide levels.

"2. Generally, small oysters up to the size of a shilling suffered most; there is a quantity of mature oysters dead also.

"3. The greatest mortality is from about one-quarter to half-tide level (reckoned from high tide mark). Very few died near low water mark.

"4. The greatest mortality occurred on leases with an easterly, northerly and westerly aspect. Very few died on portions with a southerly aspect.

"5. There are no well marked points of similarity between the present mortality and those that occur during the winter. No dead oysters could be found amongst those growing on the mangroves where they were shaded from the sun, or amongst those partially covered with mud. The mortality was expected and looked for after the great heat on the 8th and 15th February".

The features of this mortality show no analogy with those on the George's River, with the exception that in both cases the mangrove oysters survived, but on the Clyde River this is obviously accounted for by the shade received from the leaves and branches of the trees; this explanation cannot account for the survival of the mangrove oysters on the George's River during the winter—the trees do not protect them from the extreme cold. On the Clyde River the oysters were affected just where and at the age one would expect as the result of extreme heat; on the George's River, however, the mortality was greatest where the cold could not affect them. The evidence obtained from the Clyde River is therefore helpful in further eliminating low temperature as the direct cause of the mortality on the George's River.

Suggested Remedy.

As a result of the experiments carried out on the George's River, the remedy which at once suggests itself is the raising of the oysters well above half tide level during the winter months, June, July, August and September. This can be accomplished without difficulty in the case of the trays, by using longer supporting posts, so that instead of being a foot above the mud, they can be raised a further two feet or so; it would be necessary to transfer the oysters from the shell beds to elevated trays, but the greatest difficulty will be encountered with regard to those oysters growing on the stones. The labour and expense involved in transferring the stones to a higher level precludes its adoption, while if any attempt is made to remove the spat a large proportion of the shells will break; fortunately, however, there is less urgent necessity for their removal because they are usually but little affected. The older oysters can be easily knocked off the sandstone and transferred to trays where they may complete development, elevated in the winter and lowered during the remainder of the year.

The question of the effect on the growth of the shells caused by raising the oysters must be given due consideration, for it is in the winter months that the greatest increase of shell growth occurs, probably to provide accommodation not only for normal expansion as the oyster grows, but also for the great increase in size of the reproductive organ which usually begins development in the spring. There is no doubt that the growth of the shells placed on the high trays during the winters of 1924 and 1925 was considerably checked. When the trays are lowered to half tide level late in September or early in October, an immediate and rapid growth of shell may be expected, and the development of the reproductive organ retarded until the expansion of the shell is sufficient to accommodate it. The result may show in the subsequent spawning, which may be delayed till later in the summer. It is possible, though I think by no means probable, that it may retard the growth and development of the oyster to such an extent that it may take four instead of the normal three years to become of marketable size and condition, and the question then arises—is it going to pay? Unquestionably, I think it will. If it results in saving the lives of the oysters so treated, it must compensate for the labour involved and for the slower development, for

the mortality, if at all severe, makes such inroads on the return received from the reduced numbers of oysters marketable, that at the present time oyster growing on the George's River in many areas is not a profitable venture.

The Inspector of Fisheries stationed on the river, made, in 1923, a careful survey of the damage caused by the mortality in the winter of that year, and in a report submitted to his Department, estimated the loss at £10,000, which the majority of the lessees regard as a conservative estimate. The cost of raising the oysters during the cold weather must, I think, after careful consideration of all the conditions involved, total a mere fraction of that amount, hence this remedy gives every indication of being a financially sound one.

Chilling Experiments.

In an endeavour to discover the critical (low) temperature of oysters on the George's River, experiments were carried out by chilling them artificially by means of ice or a combination of ice and salt.

Experiment 1.—In this experiment a small freezer was used consisting of an inner chamber, in which the oysters were placed, surrounded by an outer chamber which was packed with alternate layers of ice and salt, a thin metal partition separating the two chambers. Both compartments were fitted with tightly sealed lids. A number of experiments had previously been made with oysters submerged in sea water in the inner chamber, but the temperatures of the water at the edges of the chamber and the middle varied so greatly, as did also that at the bottom from that at the surface, that it was found impossible to determine accurately, without opening each individual, the temperature to which it was subject. On this account this line of research was abandoned. When the inner chamber contained oysters in air only, it was found that the lower portion of it attained a lower temperature than the upper area; for this reason the oysters were laid in horizontal layers, so that when one of each layer was removed and the temperature of the internal tissues was recorded, it could be safely assumed that the temperature of the remaining oysters in that layer corresponded with that of the one opened.

On July 18 thirteen oysters were placed in the inner chamber in three layers and were removed in batches at intervals afterwards, one of each batch being opened immediately after removal and a thermometer thrust well into its body. The length of time these oysters were in the freezer and the temperature of their meats when removed are shown in the following table:

Batch No.	Number of oysters removed from freezer.	Length of time in freezer.	Temperature of body when removed from freezer.
A	3	1 hour	28° F.
B	4	2½ hours	22° F.
C	3	3½ hours	20° F.

In each case the oysters which were opened were found to be frozen, those in A only partially, while those in B and C were quite hard, so that some difficulty was experienced in forcing the thermometer into the tissues.

The three lots were laid after removal from the freezer on separate compartments of a wire-netting tray, and placed alongside the other trays on the beds at half tide level.

The three oysters in batch C were found to be gaping two days after they were frozen, though they may have died sooner. Of batch B two were dead on July 20, and the remaining two did not gape until September 3, approximately one month and three weeks after they were frozen; one of these, however, probably died a few days previously. Of those in batch A, one was found to be dead on July 26, one on September 3, and the third on September 12.

Owing to the small number of oysters used in this experiment, due to the limited capacity of the freezer, it is unsafe to generalize as the result of it, though it is significant that every oyster died even when the tissues were frozen but slightly. The length of time that elapses, up to nearly two months, between the freezing of the tissues and the death of the oyster is noteworthy. If a general mortality were caused on the beds by this agency, it becomes apparent that it would be spread over a considerable period, and the determination of the actual time when the freezing occurred would become a difficult problem. The temperature of 28° F. which killed the oysters in batch A, is approximately 1° lower than the freezing point of the salt water usually found at Shell Point. Now, from many observations made of the relative temperatures of oyster meats and the surrounding air or water, as the case may be, it may be stated that the temperature of the meat approximates very closely to that of the element surrounding it, when it is maintained for any length of time. Therefore a temperature of 28° F. may be attained within oysters surrounded by that temperature, and if this occurs naturally this experiment would lead to the conclusion that a very heavy mortality would result. But is this temperature ever reached on the oyster beds on the George's River? During the winter of 1924 the lowest temperature recorded was 8° higher; moreover, frosts on the beds are unknown to the lessees. But an air temperature of 28° F. would have little influence on the temperature of the water in the situations where oysters were placed below low tide level; therefore, even if 28° F. is a critical temperature for oysters in the George's River, it can have little or no bearing on the mortality that occurs there.

Experiment 2.—On August 6, 30 oysters were packed in broken ice at 10.55 a.m. after they had been lying in the sun for several hours, the temperature of the meats being 66° F. After ten minutes in ice one was removed and the temperature of the meat found to be 38·5° F., a drop of 27·5°; after fifteen minutes another was removed and the temperature of the meat was 35°; after twenty minutes, it was 34°; at the end of an hour it was 33° in one and 34° in another. At the end of six hours, two oysters opened showed a temperature of 34°. The remainder were then placed on the tray. One was dead on August 8, two on September 12, and two (which had been dead for some time previously) were found on October 29.

Experiment 3.—On August 6, at 5.40 p.m., 24 oysters were packed in broken ice, the temperature of the meats beforehand being 56° F. They were removed at 7.40 a.m. on the following day, after being in ice for 14 hours, and placed on the experimental tray. One was found dead on August 25, and the remaining 23 survived.

Experiment 4.—On August 13, at 3 p.m., 44 oysters were packed in ice, the temperature of the meats beforehand being 63° F. At 3 p.m. on the following day, after being in ice for 24 hours, 20 of the oysters were taken out and placed

on the experimental tray. The remainder were repacked, and at the end of another 24 hours, 15 were transferred to the tray. At 3 p.m. on August 16, the remaining 9 oysters, having been in ice for 72 hours, were removed to the tray.

Of those that had been in ice for 24 hours, one was found dead on August 25, one on September 12, and two on October 29.

Of those in ice for 48 hours, two were found dead on October 29.

Of those in ice for 72 hours, one was found dead on August 28, one on September 12, and one on October 29.

A summary of experiments 2, 3 and 4 is given in the following table:

Number of experiment.	Number of oysters used.	Temperature of oyster before packed in ice in degrees F.	Length of time in ice.	Number since dead.	Percentage of dead oysters to the total.
2	30	66	6 hours	5	17%
3	24	56	14 hours	1	4%
4A	20	63	24 hours	4	20%
4B	15	63	48 hours	2	13%
4C	9	63	72 hours	3	33%

The survival of the majority of the oysters that were packed in ice for 72 hours was surprising. Each oyster was carefully separated so that the ice might be in contact with the whole of the shell, a thorough and uniform chilling being thereby ensured. It is not possible that the oysters on the beds can ever be subject to a surrounding temperature of 32°-34° F. for such long duration, because even if the air temperatures during the night are so low, there are respites caused not only by the intervening warmth of the air during the day, but also by the higher temperature of the water which must cover the oysters for a considerable time in every period of twenty-four hours.

It is interesting again to note the varying length of time that elapses between the chilling of the oysters and their subsequent death.

The results of this series of experiments in the chilling of oysters cannot be accepted too literally; rather do they allow of a broad interpretation only, for the reason that the number of oysters used was very small, and also because it would be necessary to perform each individual experiment a number of times, and spread over a period of some weeks, before it would be possible to arrive at a reliable estimate of the number that die. It cannot, for instance, be inferred that the percentage of the oysters that died in the isolated experiments described above would even approximate the average if similar experiments were conducted over a longer period.

The value of the experiments lies in the number of oysters that survived, rather than in the percentage that died, for the bulk of them was unaffected by conditions far more rigid than appears to be possible on the beds. The whole of the evidence points strongly to the conclusion that the oysters on the George's River are not killed by the direct influence of the low temperatures that prevail there during the winter months.

The Food of the Oyster.

The time when the mortality on the George's River was first noticed by the lessees, eight or nine years ago, synchronizes with the period when cultivation began to assume a more intense form than hitherto, and leads to consideration of the question whether an attempt is being made to grow more oysters than the available food supply in the river will maintain. With this in mind, particular attention was paid to the food consumed by the oysters during July and August, not only its extent and variation but also its nature. Food was extracted from the oysters' stomachs by slitting with scissors the mantle hood covering the palps and inserting a finely tapered pipette through the mouth and oesophagus into the stomach. By sucking the distal end of the pipette gently, the food, which is brown or yellowish-brown in the mass, is drawn into the tube.

The crystalline style was frequently withdrawn by this means. Round the head of the style there was always accumulated a mass of food, sometimes more than could be recovered from the whole cavity of the stomach. In view, therefore, of the importance of obtaining the style in order to recover all the food possible, an endeavour was always made to extract it, and this was accomplished in about 90% of cases. If the style was not withdrawn the oyster was cut open in the plane of the stomach and duodenum in order to determine whether or not it was present. The food was placed in watch-glasses, and in from half to one hour the styles dissolved completely and liberated large numbers of spirochaetes. Frequently the ciliated epithelium lining the stomach was also detached and withdrawn, but owing to its transparency in contrast with the brown colour of the food, it had no influence on the estimate of the amount of food present.

It was found that oysters growing between tide marks lose their styles between every tide, though they take longer to dissolve than when they are removed from opened oysters; they are quickly re-formed when the oysters are again submerged, provided they open their shells. During the investigation of 1924, styles were invariably found in oysters that had been feeding, and according to Spärck such oysters would appear to be normally healthy, for he states that "the crystalline style is always lacking when, for some reason or other, there is anything amiss with the oyster. In winter when the death rate has been high, owing to the cold, in summer when the same thing occurs, on account of the heat, when food is wanting, when the animal lies dry, when it is infected, in every single case the crystalline style is lacking. It is, therefore, my opinion that the absence of the crystalline style must be interpreted as an indication of something not quite normal, as for instance, as regards the state of metabolism and nutrition. It is of practical importance that information of the 'state of health' of a stock of oysters (for instance in a basin or the like) can always be obtained by opening some of them and examining whether the crystalline style is present or not".

No such indication was given by any of the oysters opened during this investigation; the styles were not only present, but they appeared to be perfectly normal; at least no difference could be detected between them and those of other oysters opened during the summer in other rivers. They were mostly translucent or pale yellowish, and averaged about three-quarters of an inch in length, the largest seen measuring an inch. Nor did the liver (hepato-pancreas) give any positive indication of disordered oysters. In many instances it was not the deep brown colour of very healthy oysters, but it was never the very light colour so frequently noticed in very weak specimens.

The volume of food obtained was found to vary very considerably, and careful attention was therefore bestowed on the conditions which operated to cause the

variation. The principal causes contributing to it were found to be (1) the temperature of the water; (2) the direction and temperature of the wind; and (3) the state of the tide.

(1) The temperature of the water.—It was found, as was pointed out when discussing the influence of temperature on the vitality of the oyster, that oysters will not open to feed at a temperature of or below 50° F. On two occasions food was extracted from oysters at such low temperatures, once when it was 48° F., and again at 50° F. In both cases, with the tide about half flood, an almost negligible amount of food was obtained. It was found that at higher temperatures more food was recovered from the stomachs than at lower temperatures, provided that the wind was in the same direction, and the state of the tide the same.

(2) The direction and temperature of the wind.—It was found that these played an important part in influencing the amount of food available. During a cold westerly or south-westerly, the food was found to diminish consistently irrespective of the state of the tide; with the advent of the warmer north-easterly, the food supply invariably increased markedly. It was noticed that a north-east breeze was accompanied by an apparent dirtiness of the water, which cleared again with the return of the westerly. This may possibly be explained by the fact that the westerly, being colder than the water, cools the surface and by convection causes a downward current which takes matter in suspension with it, whereas the north-east wind, being warmer than the surface water, raises its temperature and thereby creates an upward current which carries minute organisms, detritus, etc., from the bottom to such an extent that the water assumes a more or less dirty appearance.

(3) The state of the tide.—Comparisons made of the amount of food obtained at different states of the tide, both on the flood and the ebb, and although good grounds were furnished for the statement that feeding was going on during both tides, it was almost invariably found that more food was obtained on the flood than the ebb, except during the first hour or so after high water, when much of the food taken into the stomach during the flood tide still remained there. The explanation of the greater amount of food accumulated in the stomach during the flood tide, may be the simple one that sufficient has been obtained for the oyster's requirements, leading to rejection of food on the ebb tide—or the more likely one that food may be more abundant on the flood than the ebb tide. Whatever the explanation, there is no doubt that the gills continue to pass the food forward towards the mouth so long as the oyster remains open, and after many observations, I have come to the conclusion that it remains open just as long on the ebb tide as on the flood. Therefore, if the food is as abundant on the ebb as on the flood tide, considerable quantities must be rejected by the palps.

Quantity of Food.

The amount of food obtained from the stomachs of oysters on the George's River during July and August was never very great; it was certainly not as plentiful as that which, during previous investigations, had been obtained from oysters on other rivers. But previous investigations had always been made during the warmer months of the year, therefore, in order that comparative tests might be made at the same time as those on the George's River, a visit was made to Port Hacking, situated a few miles south, on August 20. At Port Hacking, conditions are not entirely favourable to oyster life. It is an arm of the sea into which practically no fresh water flows, and therefore the oysters, although

occurring in prolific numbers, grow very slowly and never reach a large size. The water is always clear, and its salinity very high; it was therefore thought that little food would be obtained. On the contrary, more food was extracted from the stomachs of the oysters there than at any time previously during the winter on the George's River, in spite of the fact that it was with difficulty that a dozen oysters were found sufficiently large to be used for the purpose. The oysters were obtained just below the level of the water; the tide was approximately one hour on the ebb; the temperature of the water 58° F., salinity 1·022, and the wind a very light southerly.

Although the result of one record does not provide sufficient evidence on which to generalize, still the conditions obtaining when that record was made were similar to those found on several occasions on the George's River when food was obtained in much smaller quantities, and therefore there is considerable justification for the assumption that the food in the stomachs of the Port Hacking oysters was quite a normal amount.

On the following day, August 21, a visit was made to the Hawkesbury River in order to study, amongst other things, the quantity and types of food consumed by the oysters there. Food was extracted from the stomachs of twelve oysters which were growing on a mangrove stick in the "Gut", west of the railway embankment. Here there were upwards of 100,000 sticks under close cultivation on a comparatively small area of ground, and each stick had attached to it an average of probably three dozen oysters. A large volume of fresh water is continually pouring into the Hawkesbury River, and the growth of oysters west of the railway bridge is very rapid. Food was found in the stomachs of the oysters in great abundance, probably three times as much being extracted from the stomach of each oyster as was obtained from any one oyster on the George's River at any period hitherto. The tide was about one hour on the ebb; the temperature of the water was 61° F., salinity 1·018, and the wind calm, with an occasional zephyr from the north-east. Admittedly, these conditions were favourable to an abundance of food, but similar conditions, with the exception of greater salinity, had obtained on the George's River, and always very much less food was found.

In the light of the evidence obtained at Port Hacking and the Hawkesbury River, a shortage of food was strongly suspected as perhaps having some relation to the mortality which occurs in the George's River. The localities where the mortality is greatest, however, must at once negative such a supposition. If there were a shortage of food, it is reasonable to conclude that those oysters that are covered with water for the shortest length of time would be the first to starve. Generally speaking, they die least. It has almost always happened that the lower down the oysters have been, and therefore the greater length of time they have been submerged, the more severe has been the mortality, whilst those grown high up where they are covered with water for a comparatively short time have usually escaped. During the winter of 1924, the only situations where an abnormal mortality occurred at Shell Point and the head of Woolooware Bay were below half tide level. In the winters of both 1924 and 1925, of the oysters on the high trays, which were covered with water for about one and a half hours only at mean high tide, and were frequently not submerged at all when the tide was a small one, none died. Below low tide where the oysters had the whole twenty-four hours at their disposal for procuring their food, from 20% to 44% died in 1924, and from 34% to 48% died in 1925. Moreover, these oysters were

growing on trays separated from each other by about twenty yards and were about the same distance from the nearest cultivation, so that the question of overcrowding does not occur there. Therefore, in spite of the apparent paucity of the food supply, as shown by the amount extracted from the oysters' stomachs, the distribution of the mortality must seemingly eliminate the lack of sufficient food as a possible cause.

There is no doubt that in the winter months the amount of food available to the oyster is considerably less than during the warmer period of the year, but this is probably compensated for by the fact that the oyster requires less during that period. In the case of the oyster previously mentioned as having lived for 18 days with one shell removed, no evidence was seen of any food at all in the rectum during that period.

It has been found that the European species (*O. edulis*) ingests a remarkably small amount of food during the winter, Savage (1925, p. 28) stating that "The feeding period extended from July to October or November, with a short season of brisk feeding during August and September. During the remainder of the year there was very little food found". Savage also (p. 17) records the fact that many winter samples of food washed out of the oyster's digestive tract were so small that he "put the entire food contents of six oysters on to one microscope slide, in order to count the organisms".

Spärck (1925, p. 74 of reprint) also states, "I have had an opportunity of seeing several oysters also in the winter and of examining their stomachs and intestines, and most often I have not found anything during the period from the last days of November to the middle of March. The only thing which can in the winter be pressed out of the rectum of the oyster are cells of epithelium and suchlike; the ordinary characteristic intestinal contents are wanting", and further, "at lower temperatures oysters may live for a long time without any food at all, at any rate no kind of contents of the intestine is to be stated. I have had them in aquaria for 3-4 months without supplying any food to the aquarium, and without finding anything in the intestines".

The feeding habits of *O. cucullata* certainly do not agree with those of *O. edulis* in this particular. The food consumed in the winter is less than that obtained during the summer, but it is far from negligible; indeed, there are occasions when little or no variation can be seen, and it is probable that the difference in the temperature of the water in which the two species grow is the greatest factor controlling the amount of food procured.

The greater amount of food required by the oyster during the warmer period of the year may be attributed to an increase of metabolism, of general activity, and to the development of the relatively enormous reproductive organ, in the cells of which nutriment must be stored to nourish the embryo in its early stages of cell division. During the winter the reproductive organ is dormant, and the oyster's greatest activity is, as has been stated, in the direction of enlarging the shell, the constituents of which are probably obtained, not from the food, but from the water.

Types of Food.

In view of the possibility that not only the volume of food, but also the nature of it, might have some bearing on the mortality, careful attention was paid to the types of food obtained from the oysters. With this object a daily examination was made while the material was still fresh, the oysters being procured from various situations such as from the stones, trays and shell beds, and at different states of the tide.

Amongst the organisms found, two very small unicellular types invariably predominated, and diatoms, which appear to constitute the bulk of the food of the American oyster (*O. elongata*) and occasionally contribute largely to that of the European species (*O. edulis*) were always found in very small numbers. For a time I was of the opinion that the great bulk of the food consisted of these minute organisms, but one is apt to overestimate their proportion amongst the structureless material (organic detritus) because of their defined form in contrast with the indefinite nature of the detritus. Undoubtedly, considerable quantities of detritus were mostly present, though in the aggregate I still think that the unicellular types predominated.

These organisms (which I have not succeeded in having identified) occurred in about equal numbers; they differed considerably in size, the smaller type varying in length from 0·012 mm. to 0·020 mm. and in width from 0·010 mm. to 0·017 mm.; measurement of a large range of specimens indicated an average length of 0·018 mm. and a width of 0·015 mm. In shape they were broadly oval and in colour yellowish-green. The larger type varied in length from 0·030 mm. to 0·033 mm. and in width from 0·017 mm. to 0·022 mm., the average length being 0·032 mm. and width 0·021 mm. These were also yellowish-green, and the shape oval, with an unsymmetrical indentation at one end. The protoplasm was not always uniformly distributed throughout the cell, the indented end being frequently empty.

The remainder of the stomach contents consisted of diatoms, particularly *Pleurosigma*, *Navicula*, *Coscinodiscus* and *Bacillaria*, sponge spicules, confervae, portions of epidermis of larger algae, fragments of larval crustacea and minute sand grains. On several occasions, considerable numbers of cup-shaped infusoria, which at all times abounded in the water, were found in the stomachs. Owing to the fact that these infusoria are relatively fast swimmers, it is unlikely that they would be captured alive, but would probably be swept in with the current produced by the cilia of the gills after death, while still in suspension in the water.

Comparison of the food obtained from the oysters at Port Hacking and at the Hawkesbury River during August, 1924, with that of the George's River oysters, showed no noteworthy differences, except that there was a greater proportion of detritus in that from the Hawkesbury and probably less in that from Port Hacking. Excluding the detritus the bulk of the food was made up of the same minute organisms, and in all the samples diatoms were scarce. The Inspector of Fisheries and the lessees on the Hawkesbury River are emphatic that no winter mortality occurs there, and therefore the nature of the food obtained by the George's River oysters, corresponding as it does so closely with that consumed on the Hawkesbury, appears to have no bearing whatever on the mortality that occurs there.

Plankton.

In order to determine whether the water of the George's River contained any micro-organisms which might be detrimental to oyster life, a plankton net was towed over the leases daily, from July 21 to August 22, and a careful examination was made while the material was still alive. The net used for this purpose consisted of bolting or milling silk, No. 16, 157 meshes to the inch, the finest obtainable in Sydney. It was made in the form of a cone, the wide opening being sewn to a hoop of galvanised wire, 12 inches in diameter, the narrow end having an opening one inch in diameter to allow of the insertion of a bottle. The net was towed regularly at or just beneath the surface for ten minutes, approximately five minutes with the tide and five against it. The temperature of the water ranged

from 50° F. to 64° F., and the salinity from 1·018 to 1·0225. The state of the tide ranged from high water to the very lowest ebb; in the latter case the net was towed outside the leases. The wind varied from N.W. to W., S.W., S., S.E., and N.E.

Then, too, considerable quantities of the water over the oyster beds were on several occasions filtered through filter paper.

The commonest animal captured in the net was the infusorian (*Tintinnopsis* ?)* mentioned previously as occurring in the stomachs of oysters. It is roughly cup-shaped, light bluish-grey in colour, the appearance of the surface suggesting that it is covered with minute sand grains. The ciliated retractile velum, circular in outline, projects beyond the mouth when the animal is swimming. Measurements of twenty specimens taken at random showed its length to vary from 0·06 mm. to 0·09 mm., and its greatest width from 0·05 mm. to 0·06 mm., the average length being 0·078 mm. and width 0·052 mm. It was always prevalent in the water, and at times very abundant. Next in point of numbers was a larval gasteropod, which although always present in considerable numbers, was never so common as the infusorian.

Nauplius larvae of crustacea were at all times common, and an early larval stage of the mud-worm (*Polydora*) was frequently seen; the nauplius of the barnacle was very prevalent. Cold water, as low as 50° F., made no appreciable difference to the numbers of the common species captured, and their activity appeared to have in no way diminished.

When, on August 20, Port Hacking was visited, the net was towed twice in the south-west arm for periods of ten minutes, once on the flood and again on the ebb, the temperature of the water being in both cases 58° F., and the salinity 1·022. The plankton obtained approximated very closely in numbers and variety with that of the George's River.

Again, on August 21, the net was towed on both flood and ebb tides in the "Gut", Hawkesbury River, the temperature of the water on the first occasion being 60° F., and on the second 61° F., and the salinity 1·019 on the flood tide and 1·018 on the ebb. Here, also, the material obtained agreed in the main with that found in the George's River; the cup-shaped infusoria largely predominated, the larval gasteropods were numerous; and the larval crustacea of the same principal types occurred plentifully.

On September 18, the plankton net was towed near trays on the Woronora River (a tributary of the George's), where a very large percentage of the oysters had recently died, for it was thought that if any animal or vegetable life were the cause of death, specimens would assuredly be obtained there in considerable quantities, but little variation was found from the types procured earlier in the winter at Shell Point.

If there were any organisms in the water sufficient to cause the death of large numbers of oysters, they would certainly be found in extreme abundance, and a careful watch was kept for large numbers of Peridinea, a species of which, *Glenodinium rubrum*, accounted for a heavy mortality of marine life, including oysters, in Port Jackson in March, 1891 (Whitelegge, 1891), when they multiplied

* It is regretted that specific determinations cannot be given of the planktonic forms, and of those which appear in the oysters' stomachs, but the salt-water plankton of Australian shores has never been the object of specialized study; indeed, very little attention at all has been given to it. It is to be hoped that in the future its importance will be recognized, particularly in its relation to the economics of our fishery resources, for the successful study of many of the problems of our fisheries is dependent on a knowledge of the marine plankton.

so enormously that the water over large areas was discoloured a blood-red. Peridinea of various species at times enter largely into the food of oysters and other animals, including vertebrates such as the sardine, and are a source of considerable nourishment; therefore their harmful effects in Port Jackson were thought by Whitelegge to have been attributed to their extreme abundance which resulted in the suffocation of other forms of marine life.

Although no red discolouration has ever been seen by the lessees in the George's River, it was thought possible that other colourless species, whose presence could not so easily be detected, might have a seasonal occurrence in such numbers as to affect the oyster life. However, during the whole of the investigation Peridinea were never prevalent; in fact, their numbers, compared with those found in other rivers during the summer months, appeared to be subnormal.

Algae Known as "Slime", Considered as a Possible Cause of Mortality.*

Early in August a report was received by the State Fisheries from the Inspector stationed on the Clyde River to the effect that a filamentous alga, known to the fishermen as "slime", was suspected of being responsible for the mortality which occurs there frequently during the winter months. This fine seaweed, brown in colour, floats about and collects in extensive slimy masses on anything that is lying for even a short time in the water. It causes endless trouble to fishermen by clogging their nets. When the tide ebbs, large quantities are frequently left lying to a depth of several inches on the oyster beds.

Upon receipt of this report, a search was made for the weed in order to experiment with it. For several days very little was found, but on August 18 sufficient was procured for experimental purposes. An accumulator jar was filled with 3½ gallons of sea water, and twelve oysters were laid on a wire-netting frame suspended four inches from the surface, the space above the oysters being then filled with the seaweed. Twelve oysters were similarly placed in another accumulator jar, without weed, as a control. Here they were allowed to remain for a week, during which time the oysters in both jars were frequently seen with their shells open. They were then placed on the experimental tray at half tide level, and at the end of October one of each lot was found to be dead. Of course this isolated experiment cannot be accepted as proving definitely that the weed will not kill the oysters, but they were certainly covered with it under more adverse conditions of aeration, etc., than would ever be met with in nature, and even under these circumstances it gave no indication of toxicity.

Of perhaps more value was the evidence procured where the mortality was very heavy in the Woronora River. Here oysters died freely on a vertical concrete wall, and on the roof of a cave which was left exposed at low tide, where large quantities of "slime" could not accumulate. Then, too, the oysters growing on the under surfaces of the stones used in cultivation die in large numbers, and further proof is thus afforded that the mortality is in no way attributable to the deposition of quantities of this weed on the beds; furthermore, I am assured by the lessees on the George's River that the mortality has occurred in winters when there have been inappreciable quantities of this seaweed in the river.

I have previously seen heavy losses of oysters through the deposition of large quantities of fine red algae (*Falkenbergia*) on the beds. This weed, carried in suspension in the water, periodically invades Port Macquarie from the ocean,

* This has been kindly identified by Mr. A. H. S. Lucas as a species of *Ectocarpus*, probably *E. sordidus* Harvey.

entering the Port on the flood tide. At times it is so dense that the water assumes a ruddy appearance. The receding tides leave it thick on the beds, where it putrefies and liberates sulphuretted hydrogen in sufficient quantities to kill many of the oysters. The odour of the sulphuretted hydrogen from this source is at times pronounced in the adjacent township. There appears to be a large bed of this weed east or north-east of Port Macquarie, which occasionally becomes disrupted, possibly as the result of heavy weather.

Parasites, etc.

Search was frequently made for parasites, though time did not allow of any oyster being worked over thoroughly; usually only the gonad, stomach and rectum were examined. Although no parasites were found, the evidence cannot be considered as conclusive in respect to them, owing to the limited amount of material examined.

Myolitic spindles, which were found by Orton (1923) to be abundant in the tissues of hockley oysters, were not observed in fresh material nor in sections of various organs prepared in the usual way.

The salinity of the water appeared to be quite normal; it was consistently high in the vicinity of Shell Point, where most of the records were made; this was to be expected from its proximity to Botany Bay. After long-continued rain a fresh may come down from the head of the river and from the head of the Woronora, but it rarely lasts long enough to kill the oysters *per se*; at times, however, many oysters growing in the upper reaches are smothered by a heavy deposit of mud brought down in suspension. There was no semblance of a freshet during the winter of 1924.

It is worthy of note that for a number of years past the amount of *Zostera* in the river appears to have declined greatly. Although I have no personal knowledge of this decline it has been noticed by both the oyster lessees and fishermen, and also by the Inspector of Fisheries, who state that years ago there were very large beds of this plant in shallow water areas where today it occurs but sparsely, and in some cases has disappeared altogether. Some lessees affirm that the first occurrences of the mortality mark the beginning of the decline of the *Zostera*, but this statement must be accepted with reservation, for the commencement of a gradual decline would be difficult to assign to a definite period without very careful observation before and during the initial stages, and it is questionable whether its occurrence at that time would excite sufficient interest or appear of sufficient importance to call for such care.

Whether there is possibly some relation between the decline of the *Zostera* and the mortality of the oysters would under any circumstances be difficult to determine; marine ecology is a subject so involved and so little understood that the dependence of oyster life on an abundance of *Zostera* is a problem on which our present knowledge of the subject would not enable much light to be thrown. The question of *Zostera* as a source of food occurs, but it has been shown that the distribution of the mortality is so strongly against a scarcity of food as a possible cause, that this aspect does not appear to warrant further attention.

Consideration was given to the question of pollution, for the northern shores of Botany Bay are bordered by a large number of manufacturing establishments. Over these the Inspector of Fisheries keeps a strict supervision, and there does not appear to be much possibility of pollution without his knowledge of it. If pollution did occur in an amount sufficient to kill the oysters in the George's River,

many miles away, it would be of such a concentration in proximity to its source that the fish and prawns would certainly be killed in large numbers, and the fishermen engaged in their capture would lose no time in protesting. Moreover, in case of such pollution the oysters growing near the mouth of the river may reasonably be expected to die in greater numbers than those situated five or six miles up the river where much greater dilution must occur. Then there are sewer outlets situated a few miles further north along the coast; it was thought that a southerly current might bring pollution from this source within the range of oyster life. But the effect of such pollution on the oysters would more likely be noticed in the warmer months of the year; moreover, the rivers south of the George's River, where winter mortalities also occur with similar characteristics, are unquestionably free from contamination from such a source.

Observations on an Extensive Mortality on the Woronora River and on the George's River Near its Vicinity in August-September, 1924.

About the middle of September a report was received that a heavy mortality had occurred in the Woronora River and in the main river for some distance east and west of the entrance of the Woronora into it. A visit was made there on September 18, when it was found that from about 50% to 80% of the oysters on trays on the western shore of the Woronora were gaping, while the mortality on the eastern shore was a light one. On the main river above the railway bridge a large percentage of the oysters attached to the stones was dead on the northern shore, and of those on trays on the southern shore the mortality varied in different situations from a light to a heavy one.

Most of the shells were found to be empty and showed indications that the oysters had died probably some weeks earlier, while a considerable number contained the oysters in an advanced state of putrefaction. No freshly dead oysters could be found. The trays in the Woronora where the mortality was heaviest were below half tide level; they were sheltered from north-west, west and south-west winds by high hills. No record of temperatures in this locality was obtained during the winter, but for the reasons already stated it is highly improbable that they were lower than at Shell Point.

Nearby was a vertical concrete wall to which a large number of oysters was attached, and a considerable percentage of these was also dead, many of them at such a height from the bottom that the water would be three or four feet deep when it covered them.

As previously stated under their respective headings, the plankton in the water adjacent to and over the beds, and the food obtained from the stomachs of surviving oysters, showed little if any variation from those examined at Shell Point.

From the physical conditions which were found to obtain, no explanation of the possible cause presented itself, and therefore numbers of oysters which still remained alive were procured for laboratory examination.

When these were opened, a striking abnormality was noticed in the form of yellow or yellowish-brown spots distributed over the surface tissues. They varied from 1 mm. to 6 mm. in diameter, and were commonest on the labial palps, the gills and the inner surfaces of the mantles (Plate xxx, figs. 4-6), and less frequently on the surface of the gonad. In its early stages this spot has the appearance of an inflammation of the surface tissues, and later of an ulceration containing a

yellow deposit, which on examination proved to consist of blood cells (leucocytes). In many cases pieces of tissue become eaten away, particularly in the gills and palps.

When sections of the oysters were sliced off with a razor, pockets of blood cells were found in various organs of the body, such as the gonad, liver, stomach, intestine, or in the muscle.

Of one hundred oysters removed from a tray where the mortality was heaviest, every one was found either to be ulcerated or to have one or more areas of inflammation, and while many were but slightly affected, the majority showed some parts of their tissues eaten away.

On the beds where the mortality was greatest, the ulceration was most prevalent and most severe. The ratio of ulceration to mortality was fairly well defined; where approximately 80% of the oysters were dead on a tray, 100% of those remaining alive were found to be more or less affected; within half a mile, where about 50% of the oysters died, many live oysters were found free from any sign of diseased tissue. At Shell Point where the mortality could scarcely be described as abnormal, it was rare to find any inflammatory spots, and in no instance was a well defined ulceration seen during the course of the investigation although a very large number of oysters had been carefully examined. In the winter of 1925 a fairly heavy mortality occurred at Shell Point, and when the oysters still remaining alive were examined in October, numbers were seen to be ulcerated and some to have scars left by ulcerations. Probably many which had been affected had so completely recovered that no trace was left of the damaged tissue.

Pathological conditions somewhat similar to the above have been described and figured by Orton (1923, pp. 61-63, Text-fig. 6, Pl. 6, figs. 11-14), who states: "Cysts, suppurations and excretory deposits have been observed both in weak or hockley oysters and sound oysters. A suppuration may be defined for the purposes of reference here as an area of surface tissue in an unhealthy condition characterized by looseness and apparent disintegration of the tissues in the area; a corresponding condition in man would be a slightly festering sore or even an abscess, but in the oyster is to be regarded probably as a trivial complaint. A cyst may be defined as a suppuration which is resulting in the cutting out from the body of the oyster of a portion of the tissues; portions of the body excised in this way may attain such a size as 10 millimetres by 6 millimetres and may thus have serious consequences to an oyster; most cysts, however, are to be regarded as trivial. . . . Microscopic examination and chemical analysis alike have furnished no clue to even a possible positive cause, and only an explanation based on generalities can at present be offered. It is believed that similar phenomena in man would be ascribed to unsuitable diet in the minor complaints or to weak general physiological condition in the more serious instances. . . . . Microscopic examination of cysts in situ shows the cyst composed of all kinds of tissue elements, as though a piece of the body is being scooped out of the body, surrounded by a spherical shell of degenerating tissue and in turn by a layer of what may be called repair tissue. Suppurations show only degeneration of surface or sub-surface tissue, while some cysts show a sub-spherical mass of degenerating tissue under an epithelium still intact".

Microscopical examination of sections of such pathological areas in various organs of the oysters obtained from the George's River, show very similar

conditions to those described and figured by Orton, but in no case have I been able to find a layer of repair tissue containing fibroblasts surrounding the area of necrosed tissue.

The term "cyst" used by Orton does not accurately apply to the pathological condition described and figured by him. His figure 12, Plate 6, shows a mass of blood cells and apparently degenerating ova, surrounded by repair tissue consisting of young fibrous elements (fibroblasts), with the surface epithelium still intact. External to the layer of repair tissue is shown vesicular tissue which has been invaded by large numbers of blood cells—obviously an inflammatory condition. Clearly, an abscess and not a cyst is denoted. Ordinary cysts contain clear fluid and the cyst wall or base could not consist of inflammatory cells (blood cells or leucocytes). Abscesses on the other hand invariably contain inflammatory products and the wall or base of an abscess is also always infiltrated by inflammatory cells. When an abscess breaks through the surface tissues it sets free the dead leucocytes and then becomes an ulcer.

The whole of the pathological areas examined in the oysters from the George's River consisted of abscesses (internal) and ulcers (external). For instance, an adductor muscle that was progressively sliced transversely showed macroscopically a pocket of yellowish deposit of pus-like consistency surrounded by degenerating muscle tissue which in turn was walled in by apparently healthy bundles of muscle fibres. There was nowhere any outlet to the surface. Microscopic sections of such an abscess show that it consists of a central subcircular area composed almost entirely of blood cells, with here and there necrosed muscle fibres, surrounded by a dense layer of blood cells with an increasing number of degenerating muscle fibres (Plate xxxi, fig. 8). This zone may be abruptly walled in by normal muscle tissue or extend irregularly over a considerable area, in some cases with blood cells, and in others with degenerating muscle fibres predominating. The first symptom of degeneration in the muscle tissue is recognized by the breaking down of the compact bundles, the fibres becoming separated and the interspaces invaded by blood cells (Plate xxxii, fig. 10). The individual fibres gradually diminish in size and lie scattered in suspension amongst the blood cells (Plate xxxii, fig. 11, *m.f.*).

In such an abscess there may frequently be seen the migration of immense numbers of blood cells from the blood vessels, as in Plate xxxi, fig. 8, *m.l.*; here the blood cells may be followed as a well-defined stream making for the central area of the abscess.

Sections of abscesses in the gonad show similar pathological conditions. In the vesicular tissue, which is later replaced by developing sperms or ova, central areas of blood cells are surrounded by broken down vesicular tissue scattered amongst large numbers of blood cells, and this again is enclosed within the normal cells of the healthy tissue.

Such abscesses are seen in section in Pl. xxxiii, fig. 12. Here the spermatic tubules situated in the vesicular tissue beneath the surface epithelium are apparently the central areas of the abscesses. Two of these (*d*) are seen in a normal condition at the edge of the section. The outer half is lined by ciliated epithelium, the cilia serving to convey the ripe eggs or sperms to the urino-genital sinus, and the inner half is lined by germinal epithelium which gives rise to the germ cells. Masses of such germ cells, or spermatocytes (*g*), are seen invading the vesicular tissue. They are distinguished from blood cells by their greater affinity for the

stain used (haematoxylin), showing as a very deep blue. Several ducts or tubules are seen to be greatly distended and filled with blood cells (*a*), the lining epithelium having in places completely broken down; the cilia have disappeared and the germ cells have ceased development. Surrounding the ducts are aggregations of blood cells of varying density amongst disintegrating vesicular tissue. The epithelium lining the external surface of the vesicular tissue is still intact, though in the area above the abscesses it shows signs of breaking down, the cells becoming smaller and not so well defined.

When the surface epithelium completely breaks down, the abscess becomes a true ulcer (Plate xxxiii, fig. 13). The blood cells now have free access to the surface and are fast being liberated. In this condition particularly one would expect to find young fibrous tissue enclosing the innermost areas of inflammation, but it is entirely absent; in fact, in none of the sections examined has such repair tissue been seen.

It will be noticed that the intestines shown in Plate xxxiii, figs. 12 and 13 are well filled with food. Feeding has obviously been going on vigorously, and the types of food resemble very closely those seen in stained sections of the intestine of healthy oysters obtained from other rivers during the summer months.

No definite cause can be assigned to the development of the abscesses, though the condition itself appears to be the result of bacterial infection. In a similar condition in man a bacterial origin would certainly be suspected, and would result in many cases at least from a lowered resistance. In the case of the oysters there is no doubt that their vitality is lowered during the winter months; cilial activity decreases and the heart beats are very slow, and if one may reason by analogy with man, the resistance of the oysters is thereby lowered. With a weak human pulse, the susceptibility to bacterial infection is always increased owing to the more sluggish circulation of leucocytes to an infected area, and whilst a comparison of a warm-blooded with that of a cold-blooded animal is out of the question in some of their respective functions, nevertheless the microscopic appearance of the affected areas in the oyster shows such a striking similarity to abscessed areas in man, that there is little likelihood that they may have different origins.

There is no doubt that the causative agent of the abscess in the oyster is carried in the blood stream, for the abscess may be found anywhere in the body; an abscess in the centre of the muscle with a thick layer of healthy muscle tissue surrounding it on all sides, could scarcely occur there from any other source.

Suspecting that the abscesses and ulcerations had a bacterial origin, I submitted some specimens to Dr. E. W. Ferguson, Principal Microbiologist to the Department of Public Health, N.S.W. These were taken from a tray at Shell Point in November, 1925, where numbers of oysters had died during August and September, and where a small percentage of those still remaining alive were found to possess ulcers. Dr. Ferguson reported as follows:

"Three dozen oysters were opened, in only one of which was distinct evidence of ulceration visible.

"Cultures in broth were made from the infected area and incubated at 37° C. for several days. No apparent growth was present in the broth, but a subculture made from the broth on to an agar slope showed a fine growth. The organism present was a small Gram-negative bacillus, which grew on agar forming

fine colonies. No liquifaction was produced on gelatine. In lactose peptone water no change was produced, that is to say no acid or gas formed. No growth occurred in glucose broth, showing that the organism was a strict aerobe.

"The organism was not further worked out. It apparently belongs to an extensive class of water bacteria and its presence in this particular oyster has no bearing on the presence of the ulceration; unfortunately, no control cultures were made with normal oysters to see if it were present in them".

Cultures of these bacteria were used in an endeavour to infect some oysters from the Manning River early in December, 1925. These were placed in two large tanks filled with sea water, in the Fish Hatchery at Port Hacking. After the lapse of two days the cultures were poured into one of the tanks, the other being used as a control. After a further period of eight days, the oysters in both tanks were examined, and many dead oysters, some of which had been dead for several days, were seen in both tanks. Numbers of the oysters which still remained alive in each tank were found to be badly ulcerated, quite as severely in the control tank as in that into which the bacteria had been placed. No evidence whatever was, therefore, obtained that the bacteria caused the ulceration, but the fact that ulcerated oysters were found in the control tank, where the water was never very cold, would seem to show that the infection is not dependent necessarily on cold water for its development, but rather that the lowered resistance of the oysters due to overcrowding, lack of food and aeration, and the putrefaction products of the dead oysters, may allow the infection to gain a foothold, which normally healthy oysters in natural surroundings would be able to resist.

The failure to isolate virulent bacteria in the ulcerated oyster submitted to Dr. Ferguson does not imply that bacteria are not the cause of the ulceration. This oyster was obtained long after the mortality on the beds had ceased, and it is possible that if bacteria had caused the ulceration they may have by this time all been overcome by the blood cells; or, perhaps, their isolation may involve a technique quite different from that employed in this case to obtain cultures.

That abscesses and ulcers may have serious consequences for an oyster will, I think, be apparent. For instance, the gills of the oyster illustrated in Plate xxx, fig. 6, are in such a state of disintegration that very great difficulty would be experienced in conveying food to the mouth; certainly a normal supply would be impossible to obtain. The diminished food supply would probably still further lower the oyster's vitality and resistance, enabling the ulcerations or abscesses to develop to such an extent that the procuring of food would be rendered impossible. Then, too, an abscess in the muscle, liver, or walls of the stomach, for instance, would seriously interfere with the functions of those organs and might quite conceivably cause the deaths of numbers of oysters so affected. Whether such infections are the direct cause of the deaths of the majority of the oysters that occur in the George's River during the winter months, it is impossible to say, though they would appear to be sufficiently serious to cause the death of a considerable percentage. It has been shown that there was, during the winter of 1924, a fairly well defined ratio of abscess or ulceration to the mortality, and it may be found that the low temperatures obtaining during the winter months so lower the vitality and consequently the resistance of the oysters, that they cannot throw off the bacteria which they are normally capable of resisting, and the resulting abscesses and ulcerations ultimately cause their death.

Conclusion.

Although the cause of the mortality was not determined, the results of the experiments and observations described in the foregoing pages leave little room for doubt that low temperatures are not the *direct* cause. This conclusion, when viewed in the light of the recurrence of the mortality in the coldest period of the year, and its confinement to the waters of the southern half of the coast of New South Wales, which is the southern limit of distribution of the species, is entirely contrary to all presupposed ideas and to the result I expected to obtain when beginning the investigation. That low temperatures are the *indirect* cause, must, I think, be admitted. The mortality never occurs in the warmer months of the year, but regularly appears in degrees of varying intensity with the advent of cold weather. The occurrence of a heavy mortality below low tide, where the temperature is never nearly so low as that on the beds on the foreshores and where practically little variation occurs, contrasted with the absence of mortality on elevated trays which are exposed to the lowest temperatures of the air for all but very short periods of the day and night, leads to the conclusion that the *water* with its contents or constituents is the causative agent.

No direct proof has been obtained that bacterial infection is the cause, nevertheless the evidence so far disclosed points in that direction; at the least, such a hypothesis fits in with all the facts so far elucidated. These may be summarized as follows: Those oysters which are covered with water longest die in greatest numbers; the mortality has occurred during the past nine years, which marks a period of more intense cultivation, and it is well known that bacterial infection is always assisted by close aggregation of individuals; areas of heavy mortality may be separated by areas of light mortality, where no variations in physical conditions can conceivably occur; the vitality, and therefore the resistance of the oysters is lowered during the winter months, and in this condition the oysters are more likely to become a prey to such infection; the occurrence of abscesses and ulcerations in oysters, most severe where the mortality is greatest, gives every indication of having a bacterial origin.

If a bacterial origin of the mortality is assumed, explanation must be found for one or two features of its distribution, which at first sight would appear to weigh against such a hypothesis. For instance, the trays placed below low tide level were more or less segregated and the crowding together of individuals was confined to the area of the tray (about six feet by three feet), and it may be thought that the contention that the crowding of the oysters tends to the spreading of the infection cannot apply here. But these oysters would be continually exposed to the infection, and it is quite conceivable that if they had occurred there in quantities similar to those on the foreshores, the mortality might have been very much greater.

Then again, if it is the lowered resistance due to cold that permits of the infection becoming established, one might expect those oysters on the high tray, where they are exposed to the lowest air temperatures of the night, to be less capable of resisting invasions than those below low tide whose temperatures are never so low as those exposed to the air. But although the temperatures of the latter go very much lower, they also go very much higher, and this higher (air) temperature during the course of the day may enable the oyster to throw off such attacks.

In any future investigation the possibility of bacterial infection should be given most serious consideration.

It may be contended that the records obtained during the winter of 1924 at Shell Point where the mortality was a very light one, cannot be accepted as conclusive, and may show a marked variation from similar records obtained during a severe mortality. But it must not be overlooked that in those situations where the same experiments were repeated during the following winter, when the mortality was a severe one, confirmative results were obtained. Moreover, no noteworthy dissimilarity in the questions investigated could be found in the conditions obtaining at Shell Point and those in the Woronora River where a heavy mortality did occur during the winter of 1924. A record of comparative temperatures was not obtained, but if we assume that the cold at the Woronora was more intense than at Shell Point, and that the extent of the mortality was directly dependent on the severity of the winter, then one would expect the mortality always to be greater there. This is not so; oysters have died in large numbers at Shell Point during winters when the loss in the Woronora has been negligible.

The absence of a general mortality at Shell Point during 1924 was favourable to the experiments carried out in the chilling of the oysters, for had a severe mortality occurred it would have been impossible to determine whether the subsequent death of the oysters so treated was due to artificial or to natural causes.

Owing to the limited number of oysters used in the experiments carried out during the investigation, and to the lack of opportunity for checking the results by repeating the experiments a number of times, it has been difficult in many cases to draw conclusions with certainty. In several instances, however, confirmation in some form or other has been obtained, enabling reasonably conclusive deductions to be made.

Time did not allow of a repetition of most of the experiments; the whole period of the investigation in 1924 was confined to about six weeks, and the time taken up with thermometer readings, tow-netting, food-extraction, and the careful examination which the products of these latter entailed, left so little time for experimental work, and so much was necessary, that in the absence of scientific assistance, as much new ground as possible had to be broken daily.

With regard to the comparative volumes of the food obtained from the oysters' stomachs, it may be considered that determinations are very roughly approximate without counts of the various organisms composing it. Of course, where the amounts to be compared do not differ very strikingly one may easily err in making comparisons, but where there is a great deficiency, or when two samples are being compared and the one is obviously very much greater than the other, there is little possibility of error in recognizing the approximate proportions. Counts were impracticable during the course of the investigation not only on account of the time and labour involved, but also because I did not recognize, and could not get identified, the principal forms comprising the food. It was difficult to determine whether certain forms were different species or mere growth varieties of the one species. Moreover, counts of such organisms are to my mind of uncertain value, for they do not take into consideration the organic detritus which everywhere at certain periods forms a considerable percentage of the material ingested, and is undoubtedly a valuable source of nourishment; and they cannot estimate the amount of dissolved organic material which is coming to be recognized as possessing important food value, but about which little is at present known.

If the results of the experiments carried out during the winter of 1924 and 1925, which showed the occurrence of a heavy mortality in the water and its absence high up on the foreshores, may be accepted as the prevailing distribution every winter, then the steps to be taken to avoid it are perfectly clear and in most cases straightforward. So strikingly were the results of the 1924 experiments confirmed by those of 1925 that I see no reason to doubt that they were in every way quite normal. In that case the raising of the trays during the winter months will save, if not all the oysters so treated, at any rate the great majority of them, and so restore the industry devoted to their cultivation to the flourishing condition it was in before this devastating mortality made its seasonal appearance in the river.

Acknowledgment.

I desire to acknowledge my indebtedness to Mr. Geo. Hooper, Curator of the Technological Museum, with whose sanction the researches were carried out; Mr. A. W. Wood, Officer-in-charge, State Fisheries, for providing facilities for conducting the investigation; Dr. E. W. Ferguson, Principal Microbiologist of the Department of Public Health, for preparing cultures from ulcerated oysters; Mr. Geo. Edwards, Inspector of Fisheries, for general assistance; and Mr. F. Selmon, who placed the whole of his leases and his oysters at Shell Point at my disposal for experimental purposes.

Summary.

1. The cause of the mortality was not determined.

2. Its regular occurrence during the winter months towards the southern limit of the range of the species (*O. cucullata*) pointed strongly to the cause being the direct action of low temperatures. It has been shown by experiment, however, that those oysters survive which are exposed to the cold air longest, while those submerged during the winter in the more equable temperature of the water die in large numbers.

3. No oysters were found open at a temperature of or below 50° F.

4. The vitality of an oyster is lowered at low temperatures, as is shown by the weakness of the heart's pulsations.

5. Diapedesis (bleeding) was noticed on two occasions, the leucocytes being extruded from the region of the base of the left auricle.

6. The shell affords little protection against external changes of temperature; oysters with a body temperature of 58° F. showed a drop of 15° when surrounded by ice for five minutes; others with a temperature of 66° F. showed a drop of 27·5° after being in ice for ten minutes.

7. Oysters killed by the extreme heat in the Clyde River in February, 1926, indicated no features in common, as far as their age and distribution were concerned, with those that die in the George's River.

8. Oysters whose tissues were frozen by a combination of ice and salt survived for periods up to two months afterwards; even after their tissues were frozen hard they lived for some weeks.

9. After oysters had been packed in broken ice for 72 hours the bulk of them lived when replaced on the beds.

10. The food obtained from the oysters' stomachs corresponded, in the types comprising the bulk of it, with that extracted from the stomachs of the oysters at Port Hacking and the Hawkesbury River, where no abnormal winter mortality occurs.

11. Diatoms contributed a very small percentage of the food.

12. Although the volume of the food was subnormal, it is shown that it can have no bearing on the mortality.

13. No irregularity in the occurrence or appearance of the crystalline styles could be detected; their dissolution and re-formation were quite normal; and the liver although occasionally lacking the deep brown colour of normally healthy oysters, was never seen of the very pale colour characteristic of very weak oysters.

14. The volume of the food obtained by the oysters was found to increase with a rise in the temperature of the water, with a rise in the temperature of the wind when it changed from W. to N.E., and on the flood tide as against the ebb.

15. There were no organisms in the plankton which occurred in abnormal numbers compared with those found in the Hawkesbury River and Port Hacking at the same time.

16. Where a heavy mortality occurred during the winter of 1924, many of the oysters still remaining alive had abscesses, ulcerations or inflammation of the tissues, particularly common in the labial palps, gills and inner surfaces of the mantles; they also occurred in the gonad, liver, stomach and muscle.

17. Where the mortality was greatest ulcerated oysters were most prevalent; in fact, a fairly definite ratio of ulceration to mortality was seen.

18. The cause of the abscesses and ulcerations was not determined, though the microscopic examination of the pathological areas indicates that they probably have a bacterial origin.

19. The theory is advanced that the low temperatures during the winter months so lower the vitality, and therefore the resistance, of the oysters, that they cannot throw off the bacteria, and the spread of the infection carried by the water eventually results in the death of many of the oysters affected.

20. It is shown that adverse conditions other than low temperatures, such as lack of aeration, food, and the presence of decomposition products of dead oysters, may also result in the formation of abscesses and ulcerations.

21. As a remedy it is suggested that the oysters, where practicable, be placed on elevated wire-netting trays during the months from June to September inclusive.

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EXPLANATION OF PLATES XXIX-XXXIV.

Plate xxix.

1. Sandstone slabs stuck into the mud in pairs, each leaning on its neighbour forming an inverted V. This is the most prevalent type of cultivation practised on the George's River.

2. Oysters maturing on wire-netting trays, about half tide level.

3. Oysters maturing on shell beds, about half tide level.

Plate xxx.

4. Oyster (*Ostrea cucullata*) with the left mantle folded back exposing abscesses in the mantle and the gills. Four-fifths natural size.

a. Abscesses in the mantle. a_1. Abscess in the gill. *u.* Portion of the mantle tissue eaten through.

5. Oyster with left mantle folded back exposing abscesses in the mantle, gills and labial palps. Four-fifths natural size.

a. Abscess in the mantle. a_1. Abscess in the palp. *b.* Gill tissues eaten away by ulceration. *u.* Ulceration in the gill.

6. Oyster with left mantle folded back exposing acute ulceration of the gills. Four-fifths natural size.

b. Degenerating gills caused by acute ulceration.

Plate xxxi.

7. Transverse section of normal muscle tissue of the adductor muscle. The muscle fibres are densely massed together forming bundles, which are separated by connective tissue. × 64.

8. Transverse section of portion of the adductor muscle showing an abscess and an extensive inflammatory area. This abscess occurred in the centre of the muscle, the outermost muscle fibres being in an apparently healthy condition. × 32.

a. Central area (of infection?) composed of blood cells (leucocytes) with an occasional necrosed muscle fibre. *b.v.* Blood vessel from which dense masses of blood cells (*m.l.*) are migrating toward the central area of the abscess. *d.f.* Degenerating muscle fibres with blood cells in the interspaces. *l.* Dense aggregation of blood cells surrounding the central area of the abscess (*a.*). *l.m.* Degenerating muscle fibres surrounded by copious blood cells. *m.f.* Healthy muscle tissue. *m.l.* Blood cells migrating from the blood vessel (*b.v.*) toward the central area of the abscess.

Plate xxxii.

9. The central area of the abscess in the adductor muscle. × 60.

l.c. Blood cells in the central area of the abscess. *l.m.* Dense aggregations of blood cells surrounding the central area. *n.f.* Necrosed muscle fibre.

10. Degenerating muscle tissue. × 60.

l. Blood cells. *m.f.* Degenerating muscle fibres amongst aggregations of blood cells.

11. Necrosed muscle fibres scattered amongst clusters of blood cells. × 110.

l.c. Blood cells. *m.f.* Necrosed muscle fibres.

Plate xxxiii.

12. Abscesses in the testis, the surface epithelium having begun to degenerate. × 32.

a. Abscesses in the spermatic tubules containing an abundance of blood cells. *d.* Healthy tubules from which clusters of spermatocytes (*g*) are spreading into the vesicular tissue (*v*). *e.* Degenerating surface epithelium. *e.p.* Ciliated epithelium of the intestine. *f.* Food in the intestine. *g.* Clusters of spermatocytes. *l.* Follicles of the liver (hepatopancreas). *m.* Mantle. *v.* Healthy vesicular tissue.

13. The abscess, having broken through the surface epithelium, now assumes the form of an ulceration, which allows of the expulsion of the dead blood cells. × 32.

b.v. Blood vessel. *c.* Surface epithelium. *e.p.* Ciliated epithelium of the intestine. *f.* Food in the intestine. *g.* Clusters of germ cells. *l.* Follicles of the liver. *u.* Central area of the ulceration, the dead blood cells lying free at the surface.

Plate xxxiv.

14. Abscesses shown in Pl. xxxiii, fig. 12, more highly magnified. × 80.

a. Abscess in spermatic tubule containing an abundance of blood cells. *e*. Degenerating surface epithelium. *g*. Clusters of spermatocytes. *l*. Follicles of the liver. *v*. Vesicular tissue.

15. Live blood cells (leucocytes) of the oyster, seen by dark-ground illumination. D is shown in a state of division. *n*. nucleus; *v*. vacuole. × 1,200.

The tissues from which all the sections were cut were fixed in Bles (alcohol-formol-acetic), and the sections were stained with ammoniated haematoxylin (Ehrlich) and eosin. The objectives used for the photomicrographs were 2/3, 1/3 and 1/6 inch, in each case without an ocular.

REVISION OF *ATHEMISTUS* AND *MICROTRAGUS* (FAM. CERAMBYCIDAE) WITH NOTES, AND DESCRIPTIONS OF OTHER AUSTRALIAN COLEOPTERA.

By H. J. Carter, B.A., F.E.S.

(Seven Text-figures.)

[Read 29th September, 1926.]

Buprestidae.

Polycesta mastersi Macl.—I placed this as a synonym of *Castalia bimaculata* L. (These Proc., 1924, p. 523). M. Théry has sent me a specimen of the latter and criticisms which show the distinctions of these species. There seems to be a doubt as to the correct genus of Macleay's species, which Kerremans placed under *Polycestella* in his "Monographie".

Germarica (Aphanisticus) lilliputana Thoms. = *G. casuarinae* Blkb.—I suggested this synonymy in 1909 (These Proc.), a suggestion which elicited a strong protest from Blackburn (*Trans. Roy. Soc. S. Aust.*, 1912, p. 74) on the grounds that Thomson's description was inconsistent with this in having (1) apex "subtruncata et biacuta", (2) "scarcely more than half the size of *G. casuarinae*", with further comments.

Recently Monsieur Théry has courteously sent me a specimen of *G. lilliputana* Thoms., compared with type by himself; while Mr. A. M. Lea has kindly sent me specimens for examination from South Australia. Of these, five bear the label "*Germarica casuarinae*" in Blackburn's handwriting, five others from the Blackburn Collection have printed labels "Tasmania, Blackburn", together with the name "lilliputana Thoms." also in Blackburn's handwriting. I have closely examined all these, as well as a large number of examples in my collection, under a Zeiss binocular and note as follows:—

No. 1. *G. lilliputana* Thoms. "comparé au type par A. Théry", also labelled "Coll. French Victoria". 2 mm. long. This exactly corresponds with my examples from Wahroonga (N.S.W.), Bogan River (N.S.W.), Ravenswood and Tambourine Mt. (Q.) and the Tasmanian specimens so named by Blackburn.

No. 2. *G. casuarinae* Blkb. (named by author), 2 examples, imbedded in gum on card, from Kangarella (S.A.) are respectively 3 (–) and 2 mm. long.

No. 3. *G. casuarinae* Blkb. (named by author), 1 example on card from Petersburg (S.A.) is 3 (+) mm. long.

No. 4. *G. casuarinae* Blkb. (named by author), 2 examples labelled "S. Australia Blackburn" are respectively 3 and 2 (+) mm. long.

Nos. 2, 3 and 4 correspond more or less closely with examples from Sydney, Gosford and Stradbroke Island (Q.). All are "bronze-black" and have their apices rounded, the differences between them being chiefly as to size (between the above limits) and form, the latter due to sex. I have specimens taken "in

cop."—the males generally being more or less cylindric, the females often having the abdomen enlarged; with a sinuate outline. All the specimens 1, 2, 3, 4 are closely similar in structure and sculpture, well described by Blackburn in the notes which follow his Latin diagnosis.

Any existing doubts as to the above synonymy are now entirely removed from my mind, the difference as to apical structure being due to Thomson's inaccuracy, whose casual systematic work has frequently been noted. The variations in size are probably due to local conditions. The front and middle tibiae are rather strongly curved and dilated. A figure of an antenna was recently given by me (These PROC., 1926, p. 59). The species is very widely spread over Eastern Australia including Tasmania, but I have not yet seen examples from Western Australia, though it is likely to be there. Mr. Lea—with a sharp eye for *Casuarina*-haunting insects—lately found *Germarica* spp. both in New Caledonia and the Fiji Islands that I cannot separate from *G. lilliputana* Thoms., though the Fiji specimens were of a brighter bronze colour that would justify a varietal name.

Dryopidae.

In my revision of *Helmis* (These PROC., 1926, p. 50) I omitted to state the following synonymy, though I placed the two names together in the table:—

Helmis politus King = *H. punctulatus* King.—Types examined—that of the latter being somewhat obscured by dirt.

Cerambycidae.

ATHEMISTUS Pascoe.

The discovery of four new species of *Athemistus* amongst the spoils of the University Expedition to Barrington Tops in January, 1925, has induced me to revise the genus—a task that has enabled me to more than double the number of recorded species. The close association in habit and facies of this genus with *Microtragus* led me further into an examination of this genus also. A single Australian species of *Somatidia* is herein noted—a genus numerous in New Zealand and known also in Lord Howe Island, but hitherto unrecorded from Australia.

This genus was proposed for the reception of *Parmena rugosula* Guér. Pascoe, at a later date described seven species, which were supplemented by three more by Blackburn in 1893. Thanks to the courtesy of friends and colleagues at the British and various Australian museums, I have been able to determine all of these with the possible exception of *A. funereus* Pasc., of which the type is unique, but of which I hypothetically name a specimen from the Blue Mountains in the Australian Museum. It is characterized as follows:—

? *A. funereus* Pasc. or n. sp.—Black. Fulfils the author's description as to colour, more parallel elytra, and more coarsely punctured prothorax than *A. armitagei*; but other notable distinctions are more robust antennae and the elytral pustules much more strongly raised and coarser than in that species; with two larger, subconical pustules on apical declivity. Length 8 mm.

N.B.—There are two subapical tubercles, slightly more prominent than the rest, on all the examples of *A. armitagei* Pasc. that I have seen (including one compared with type by Mr. Blair). This character was omitted by Pascoe.

The types of *A. monticola* and *A. torridus* have been sent for examination from the National Museum, Melbourne, and a cotype of *A. cristatus* from the South Australian Museum.

N.B.—In Mr. Lea's list of Blackburn types (*Trans. Roy. Soc. S. Aust.*, 1912, p. xv), that of *monticola* is included amongst those sent to the British Museum.

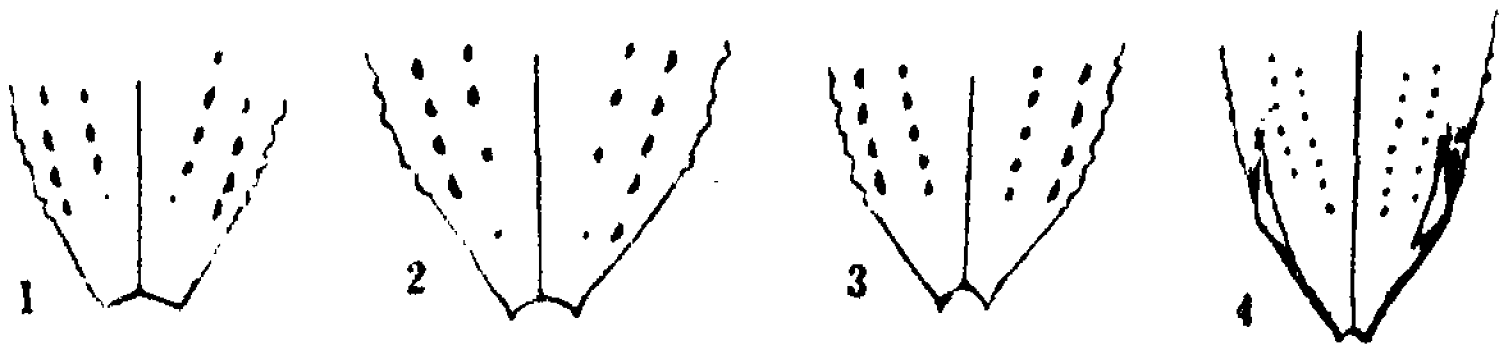
The individuals of a species vary very little and the different species are generally quite clearly separable with certain exceptions. Thus I consider *A. puncticollis* Pasc. as very variable in the size and density of its surface punctures. *A. howitti* varies in colour from reddish-brown to nearly black and in length from 10 to 16 mm.; while the elytral apices vary from being obliquely truncate to (in 1 ex.) distinctly spinose, with intermediate forms (Text-figs. 1-3). All are more or less dull in colour, brown or black, sometimes with paler areas, the derm is thick and velvety, the pronotum with lateral spines and generally with two or more additional tubercles in the same horizontal line with the lateral spines; the scutellum is very small and inconspicuous; the elytra largely covered with more or less seriate pustules, which vary in their prominence and closeness of adjustment; the majority of the species have two more prominent tubercles on the apical declivity which give a distinct character to species like *bituberculatus* and *aethiops*; the hollows between the tubercles are sometimes clothed with pubescence of a paler colour (*vide infra*). The antennae, legs and underside vary little in the different species, the first never extending the full length of the body and the general proportion of their segments similar; only in *A. macleayi*, n. sp. (of the 22 in my table) are the antennae rather more closely set than usual; the tibiae have the base and apex (the latter especially) clothed with silvery hair; the underside impunctate. The only external sexual distinction I have been able to note lies, as in *Microtragus*, in the palpi, the terminal segment of the male being always wider, clubbed, scarcely triangulate, while in the female this segment is narrow, generally elongate-lanceolate. *A. macleayi* is the species (wrongly determined by Lea as *howitti* Pasc.) that led to his note on the generic distinction of *Athemistus* from *Microtragus* (*Trans. Roy. Soc. S. Aust.*, 1917, p. 619).

They occur on the ground, under stones or logs, or sheltering in the interstices of the latter, and easily escape notice through the close adaptation of colour to their environment; and as they normally carry their antennae closely pressed to the dorsal surface they look at first sight very like Phalidurine weevils found in similar habitats. I have often found them also under dead eucalyptus boughs, which, gently raised, are shaken into an umbrella. They appear to be most numerous in the forest areas of mountain regions. Thus no less than five species occur on the Kosciusko ranges and the adjacent highlands, viz.: *armitagei* Pasc., *pubescens* Pasc., *puncticollis* Pasc., *approximatus*, n. sp. and *maculatus*, n. sp. The Blue Mountain regions contain six (*armitagei* Pasc., *cristatus* Blk., *howitti* Pasc., *aborigine*, n. sp., *approximatus*, n. sp., and *puncticeps*, n. sp.), while the Sydney University Zoological Expedition in January, 1925, took six species at Barrington Tops, e.g. *rugosulus* Guér. (at Wharton's Mill), *howitti* Pasc., *harrisoni*, n. sp., *luciae*, n. sp., *barretti*, n. sp., and *punctipennis*, n. sp.

As I have had before me a larger number of individual examples of the genus than are likely to be seen together again, it may be useful to record the respective localities given for each species.

1. *rugosulus* Guér. 20 examples, all from New South Wales: Sydney, Illawarra, Exeter, Brown Mountain, Wharton's Mill (Moonan).
2. *pubescens* Pasc. 44 examples, chiefly from Melbourne Museum or Mr. J. E. Dixon, from Gisborne, Gippsland, Victorian Alps, Greensborough, Mt. Macedon, Warburton, Bright, Wandong, Kilmore Junction, Otway Ranges, Mount Park. New South Wales: Mt. Kosciusko.

3. *armitagei* Pasc. 30 examples, all except one from New South Wales: Sydney, Blue Mts., Oberon, Rylstone, Bell, Ebor, Forest Reefs, Queanbeyan, Monaro, Kosciusko; one from Victorian Alps.
4. *aethiops* Pasc. 19 examples. Gippsland, Warburton, Dandenong Ranges (Victoria).
5. *tuberculatus* Pasc. 16 examples. Warburton, Belgrave, Westernport (Victoria).



1-3. Variations in apex of *Athemistus howitti* Pasc.
4. *Athemistus barretti*, n. sp.

6. *howitti* Pasc. 30 examples, all except one from New South Wales. Sydney, Illawarra, Mt. Irvine and Mt. Wilson, Bulahdelah, Eccleston, Clarence R., Grose Vale, Coramba, Dorrigo and one from Eltham (Victoria). (Note "Clarence River Queensland", *sic* in Pascoe's description.)
7. *puncticollis* Pasc. 32 examples. New South Wales: Mt. Kosciusko, Jindabyne, Rule's Point (Upper Murrumbidgee). Victorian Alps, etc.
8. *funereus* Pasc. 1 example (?). Blue Mts., N.S.W.
9. *cristatus* Blkb. 18 examples, all from various parts of the Blue Mts.
10. *monticola* Blkb. 5 examples. Victorian Alps and Harrietville (Victoria).
11. *torridus* Blkb. Type only from N. Queensland in Melbourne Museum.

For other species *vide infra*, under their respective descriptions.

N.B.—Only two species are so far known from Queensland, both amongst the new species described below, taken most probably by the late George Masters. All the others are from New South Wales or Victoria.

ATHEMISTUS MACLEAYI, n. sp.

Dark brown, the elytra sparsely mottled with paler patches; apex of tibiae and tarsi clothed with yellowish hairs.

Head and pronotum impunctate, antennae more closely set than usual, the interspace of ♂ about the width of the basal joint of an antenna, of ♀ rather wider. *Prothorax*: Width including tubercles, slightly wider than long, widest at middle, sides evenly rounded with four well developed tubercles, the lateral conical, the discal elongate and blunt; disc rather flat with slight declivity at base. *Scutellum* inconspicuous. *Elytra* wider than prothorax at base, well widened at, or a little behind the middle, apices separately rounded, with seriate rows of well raised elongate pustules, the five exterior rows well separated, a triple confused row on each side of suture, the paler spots under a lens showing as greyish pubescence, the most defined of these being a larger premedial macula on each side and two smaller ones on the apical declivity. *Dimensions*: ♂, 15 × 5·5 mm. ♀, 17 × 7 mm.

Habitat.—Queensland, Gayndah (in Australian and Macleay Museums, also Coll. Lea) and Stanthorpe (F. A. Perkins in Queensland Museum).

Six examples examined, of which four are apparently a part of the original Gayndah collection of Sir William Macleay, show the finest species of the genus so far known. By its impunctate pronotum and elytral surface it could only be

confused with *A. howitti* Pasc. and *A. cristatus* Blkb., from both of which it is distinguished by its large size, mottled surface and the more closely set antennae. In the last character it shows an affinity with *Microtragus*. The paler spots are little defined in two examples.

Type in the Australian Museum.

ATHEMISTUS MACULATUS, n. sp.

Chocolate-brown; frontal area and patches of the elytra with ashy pubescence; the most clearly defined being a larger premedial spot, smaller elongate markings in the humeral region and the clothing of the subapical tubercle.

Head minutely and sparsely punctate, antennae rather widely separated, a distinct medial sulcus on forehead. *Prothorax* unusually convex, about as long as wide, widest at middle, sides evenly and rather widely rounded with five small tubercles in a transverse line, the lateral and middle tubercles very small, disc apparently smooth, but under a Zeiss binocular seen to be finely punctate. *Scutellum* inconspicuous. *Elytra* scarcely wider than prothorax at base, apices separately rounded, the surface pustules flatter than usual, with about four defined series on each besides those irregularly placed; two small, round, blunt but prominent tubercles on apical declivity. Clothing of legs and tarsi as usual. *Dimensions*: 13-14 × 5-5·5 mm.

Habitat.—Mt. Kosciusko (A. J. Nicholson and Coll. Lea, National Museum, H. J. Carter).

Three examples are before me (in one case the maculae indistinct). From *bipustulatus* (*infra*) it is distinguished by colour, its thick velvety derm, more oval form, and the convex, evenly rounded and almost impunctate prothorax, with its small lateral tubercles.

Type in Macleay Museum.

ATHEMISTUS ABORIGINE, n. sp.

Elongate; black (rarely dark brown) with pale pubescence on the tarsi, apex of tibiae and on the two small tubercles on the apical declivity of the elytra.

Head with fine, rather close punctures and a few long hairs, space between base of antennae moderately wide. *Prothorax* as wide as long, wider at base than at apex, widest behind middle, with four small tubercles in a line behind the middle, the lateral more pointed and prominent; surface closely pitted with moderately large punctures (larger than in *A. puncticollis* Pasc.). *Elytra* wider than prothorax at base, widest at middle, apices separately rounded, the seriate pustules forming a small crest at shoulders, the pustules themselves elongate and little elevated (both crest and pustules less conspicuous than in *A. cristatus* Blkb.); on each side of apical declivity a small, round blunted tubercle, generally with pale clothing; the antennae of ♂ extending to this tubercle, those in ♀ distinctly shorter. *Dimensions*: 12-16 × 4·5-6 mm.

Habitat.—New South Wales: Blue Mts. (G. E. Bryant, E. W. Ferguson and H. J. Carter), Forest Reefs and Queanbeyan (A. M. Lea), Walcha (E. W. Ferguson), Monaro and Pipers Flat (Macleay Museum), Murrurundi (C. F. Denquet), Jindabyne, Bell and Capertee (H. J. Carter).

A widely distributed species in New South Wales of which twenty-three examples have been examined, that is clearly distinct from the other bituberculate species by the combination of dark colour, strong pronotal puncturation and small sub-apical tubercles.

Type in Macleay Museum.

ATHEMISTUS HARRISONI, n. sp.

Elongate; brown, antennae and legs rufous brown; covered with dense velvety derm, sometimes vaguely variegated with paler pubescence.

Head finely punctate, antennae rather widely separated; without distinct frontal sulcus. Prothorax about as wide as long, widest in middle, sides lightly and evenly rounded, with four distinct but rather small tubercles, placed more forward than usual (about half-way), disc almost impunctate in some examples, in others fine punctures showing through the derm. *Elytra* as wide as prothorax at base, rather sharply and separately rounded at apex, the elongate and little raised pustules generally in well separated series except those near suture, shoulders without any vestige of a crest; two elongate and moderately raised tubercles on apical declivity. Clothing of legs and tarsi as usual. *Dimensions*: 13-16 × 4·5-5·5 mm.

Habitat.—New South Wales: Barrington Tops (Sydney University Zoological Expedition), Guyra and Comboyne (H. J. Carter).

Eight examples before me show an elongate species near *aborigine* (except in colour) with a pronotal surface like *A. maculatus* (*supra*) or *A. howittii* Pasc., and two well defined subapical tubercles which are quite differently shaped from those in *A. bituberculatus* Pasc. In both sexes the terminal joints of the palpi are subulate though clearly wider in the ♂. Type in the Macleay Museum.

ATHEMISTUS LUCIAE, n. sp.

Pale reddish-brown; thickly clothed with velvety down with oblique line of paler pubescence from behind shoulder to the middle.

Head apparently impunctate, interspace between antennae normally wide, without frontal sulcus. *Prothorax* about as wide as long, widest behind middle, base wider than apex, sides lightly and arcuately narrowed to apex; disc sparsely but clearly punctate, except on two triangular patches at base without derm; four small but distinct tubercles in a transverse row behind middle, the two inner at the apex of the bald triangular patch. *Elytra* slightly wider than prothorax at base, apices separately rounded; pustules small, more or less seriate, the series showing most clearly on basal half, the pustules obsolete on apical declivity and there replaced by punctures; two small elongate triangular pustules on apical declivity. *Dimensions*: *8-10* × *3-4* mm.

Habitat.—New South Wales: Barrington Tops.

Three examples taken by the Sydney University Zoological Expedition. One example, more abraded than the others, is darker in colour. In the ♂ the apical joint of palpi is rather widely oval, in the ♀ subulate. It is very different from *A. aethiops* Pasc., by its pale colour, much finer surface sculpture and by the structure of pronotum (*vide* note on *aethiops*, *supra*). The oblique stripe on elytra, though distinct in the living specimen is less clear, though perceptible, in its present condition.

It is the most delicately sculptured species in the genus and I name it after Miss Lucy Wood, an energetic worker of the Expedition.

Type in the Macleay Museum.

ATHEMISTUS PUNCTIPENNIS, n. sp.

Muddy brown, pubescent, elytra with some vague ashy spots.

Head strongly punctate, both vertex and frontal area showing large, irregular punctures. *Prothorax* wider than long, sides slightly widened in the middle, the lateral spine small, two small discal pustules in a line with these behind the middle,

disc uneven, coarsely and irregularly punctate with some raised spaces. *Elytra* ovate, apices almost conjointly rounded; surface very uneven, with rows of large pustules, more or less seriate; one row of larger pustules on each extending from behind the shoulder and terminating in a large, well-raised tubercle on the apical declivity; the interspaces between rows containing large punctures, also more or less seriate, one on each side of suture distinctly so; the paler pubescence showing in patches behind the shoulder and behind the middle. *Dimensions*: 8 × 3·5 mm.

Habitat.—New South Wales: Barrington Tops (Sydney University Zoological Expedition).

Two examples, I think the sexes (from the wider palpi of one), form the third new species taken in January, 1925, by the above, all occurring under dead eucalyptus branches on the ground in the forest country at 4,800 feet altitude. It is nearer *A. aethiops* Pasc. than *A. luciae*, *supra*, but differs in its lighter colour, strongly punctate head, differently shaped prothorax, the elytra distinctly punctate and having more irregular sculpture, but the pustules themselves less elevated than in *A. aethiops*.

Type in Macleay Museum.

Athemistus laevicollis, n. sp.

Chocolate-brown with reddish pubescence, interspersed on the elytra with paler areas; base of antennal joints silvery.

Head impunctate, a fine sulcus on vertex, interspace between antennae normally wide. *Prothorax* wider than long, sides well rounded, widest behind middle, more sharply narrowed behind than in front; disc impunctate, the derm sparsely interspersed with fine, silvery recumbent hairs; with four distinct, not very large tubercles; the middle of disc forming a somewhat diamond-shaped depression limited by the two discal tubercles and in front and behind by oblique, little raised ridges. *Elytra* ovate, slightly wider than prothorax at base, apices separately rounded, with series of regular, closely packed, elongate, lightly raised pustules; a large ill-defined patch of paler pubescence at and behind the middle; two small round tubercles on the apical declivity. Base and apex of tibiae unusually thickly clad with silvery hair. *Dimensions*: 9-11 × 4 mm.

Habitat.—Ebor, Northern Tablelands of New South Wales (R. J. Tillyard).

Three examples (one, at least, male) sent me in December, 1911, with other Coleoptera taken by Dr. Tillyard.

The small size, impunctate head and pronotum, the elytra bearing the smallest definite subapical tubercles of any in the group that contains them. It is most like *A. maculatus*, *supra*, in general facies, but besides being much smaller, the pronotal sculpture is different, the elytral maculae less defined, and the seriate pustules more strongly raised.

Type in the National Museum, Melbourne.

Athemistus approximatus, n. sp.

Dark brown; base of antennal joints and parts of elytra with paler pubescence.

Head finely punctate, with sparse upright hairs. *Prothorax* wider than long, sides moderately and evenly rounded, quadrituberculate, the lateral tubercles spiniform, the discal distinct; surface uneven, rugose near base, very coarsely punctate, the punctures sparser near middle. *Elytra* narrowly ovate, apices separately rounded, an ashy macula near the middle of each, and a small tubercle on apical declivity similarly clothed, the surface pustules seriate and others crowded and rather prominent. *Dimensions*: 11-12 × 3·5-4 mm.

Habitat.—Victoria: Flinders (H. J. Carter), Wilson's Promontory (J.A.K.), Gippsland (National Museum), Meenyan (Coll. Lea). New South Wales: Brindabella (S. Australian Museum), Mt. Victoria (Lea), Kosciusko and Queanbeyan (Coll. Lea), N.S.W. (Macleay Museum).

Eleven examples before me are very near some examples of *puncticollis* Pasc., from which it is distinguished as follows:—

puncticollis Pasc.	*approximatus*, n. sp.
Pronotum punctures closer and smaller	punctures sparser and larger
discal tubercles faint or absent	discal tubercles distinct
Elytra without subapical tubercles	with two small subapical tubercles
pustules little raised, no sign of shoulder crest	pustules more strongly raised, small shoulder crest shown

Type in National Museum, Melbourne.

ATHEMISTUS PUNCTICEPS, n. sp.

Elongate-ovate; reddish-brown, antennae and legs red.

Head closely and not very finely punctate, front and labrum with long upright hairs; eyes larger and more prominent than usual. *Prothorax* as wide as long, sides well rounded, widest behind middle, quadrituberculate, lateral tubercles very small; disc finely and rather densely punctate, the punctures smaller than in *puncticollis*; disc with a diamond-shaped planate area between the discal tubercles; this emphasized by its limiting oblique ridges meeting at the middle of base. *Elytra* narrowly ovate, apices subconjointly rounded; more uniformly seriate pustulose than usual, the pustules finer near suture, then three series of well-raised nitid pustules, the second forming a small crest at shoulder, the lateral pustules again smaller. *Dimensions*: 14 × 4·5 mm.

Habitat.—New South Wales: Gingken (near Oberon) (R. B. Carter in National Museum), vicinity of Jenolan Caves (in Coll. Lea).

Two examples examined. The type was taken by my son some years ago. It is clearly distinct from *A. puncticollis*, its nearest ally, by the finer punctures of the pronotum and the much stronger and denser punctures of the head, the pilose head (and antennae), besides having a different elytral sculpture, the pustules less crowded.

Type in the National Museum, Melbourne.

ATHEMISTUS TRICOLOR, n. sp.

Reddish-brown; antennae and legs red, elytra with two white maculae at middle besides sparsely scattered reddish spots elsewhere.

Head sparsely and finely punctate. *Prothorax* as wide as long, widest behind middle, sides moderately rounded, more strongly converging behind than in front, with four large tubercles, the disc flat, coarsely and sparsely punctate, the flattened area arcuately narrowed from the discal tubercles to base. *Elytra* narrowly ovate, apices separately rounded, unevenly pustulose, with series of larger pustules leaving several depressed areas, and a row of small pustules on each side of suture; two small subtriangular tubercles on the apical declivity. *Dimensions*: 8 × 3 mm.

Habitat.—Victoria: Timboon and Forrest (H. W. Davey), also Victoria (Blackburn Coll. in South Australian Museum).

Three examples labelled as above respectively, the two first in Mr. Lea's collection are clearly distinct from *armitagei* Pasc., and *aethiops* Pasc.; from the former by its more defined bituberculate elytra, from the latter by colour and the form of the prothorax and from both by the planate pronotum in which the base appears somewhat excavated on each side of a narrow peninsula near scutellum.

Type in Coll. Lea.

ATHEMISTUS BARRETTI, n. sp. Text-fig. 4.

Fawn-coloured, pubescent, with paler markings as follows: A short oblique depression behind the shoulders, an elongate spot near middle, the declival tubercles and the surrounding region, the basal joints of antennae and legs also with light spots.

Head impunctate, frontal area and antennae having sparse upright flavous hair. *Prothorax* convex, as wide as long, sides well rounded, with prominent lateral spines and two smaller discal tubercles, a small elongate impression between these latter, and two comma-like impressions behind this at base; disc quite impunctate. *Scutellum* triangular, small but distinct. *Elytra* narrowly ovate, attenuated at apex, apices sharply obliquely truncate (subdentate), the pustules smaller and less raised than usual, the seriate pustules towards sides as well as the irregular medial ones, rather widely separated, and obsolete on apical declivity; two well raised, elongate, triangular tubercles on declivity. Knees and apices of tibiae with pale clothing. The palpi have the apical segment oval in ♂, narrow and pointed in ♀. *Dimensions*: 11 × 4 mm.

Habitat.—New South Wales: Barrington Tops (Messrs. C. Barrett, J. Hopson and H. J. Carter).

Three examples (2 ♂, 1 ♀) examined, one each taken by the above, and named after my friend the Victorian naturalist. I cannot place it amongst existing species; the bituberculate elytra at once separating it from *A. howitti* Pasc., the only other species having subspinose apices to the elytra. The finely pustulose elytra and curiously spotted femora and antennae are unlike any other species.

Type in Coll. Carter.

ATHEMISTUS MASTERSI, n. sp.

Dark brown; antennae and legs reddish.

Head and pronotum impunctate, antennae normally widely placed. Prothorax clearly wider than long, evenly and moderately widened at sides, lateral spines conical, three small discal tubercles, also two small elevations near base. *Scutellum* very small. *Elytra* slightly wider than prothorax at base, apices separately rounded; seriate pustules uniform, little raised and small, apical declivity without larger pustules. *Dimensions*: 11-11·5 × 4-4·5 mm.

Habitat.—Queensland: Ipswich, in Macleay Museum.

Two examples, I think the sexes, contain locality labels in the handwriting of the late Curator of this Museum, after whom I name it, in kindly memory of his help to me. It is nearest *laevicollis* in its impunctate pronotum, but the lateral spines are much more pronounced, while the elytral sculpture is different—somewhat as in *harrisoni*.

Type in the Macleay Museum.

Table of Athemistus.

1.	Elytra with two subapical tubercles	2
	Elytra without such tubercles	14
2.	Size large, more than 12 mm. long	3
	Size medium, 10-12 mm. long	5
	Size small, 6-9 mm. long	8
3.	Colour black (or nearly so)	*aborigine*, n. sp.
	Colour brown	4
4.	Sides of prothorax very lightly rounded	*harrisoni*, n. sp.
	Sides of prothorax widely rounded	*maculatus*, n. sp.
5.	Pronotum coarsely punctate	6
	Pronotum impunctate	7
6.	Colour reddish-brown, apical tubercles large	*bituberculatus* Pasc.
	Colour dark brown, apical tubercles small	*approximatus*, n. sp.
7.	Elytral apices separately rounded	*laevicollis*, n. sp.
	Elytral apices subdentate	*barretti*, n. sp.
8.	Colour black (or nearly so)	9
	Colour reddish-brown	10
9.	Sides of pronotum tumid in front; apical tubercles large	*aethiops* Pasc.
	Sides of pronotum normal; apical tubercles small	*funereus* Cart. (? Pasc.)
10.	Elytral surface pustules very fine	11
	Elytral surface pustules not so	12
11.	Elytral pustules crowded, apical tubercles round	*torridus* Blkb.
	Elytral pustules sparse, apical tubercles triangular	*luciae*, n. sp.
12.	Elytra with punctures besides pustules	*punctipennis*, n. sp.
	Elytra without punctures	13
13.	Pronotum sub-explanate, subapical tubercles triangular	*tricolor*, n. sp.
	Pronotum convex, subapical tubercles subobsolete	*armitagei* Pasc.
14.	Size large (more than 14 mm. long)	15
	Size medium (10-14 mm. long)	16
15.	Pronotum punctate	*rugosulus* Guér.
	Pronotum impunctate	*macleayi*, n. sp.
16.	Surface strongly pilose	*pubescens* Pasc.
	Surface not pilose	17
17.	Pronotum impunctate	18
	Pronotum more or less punctate	19
18.	Colour black, distinct crest at shoulders	*cristatus* Blkb.
	Colour brown, shoulders without crest	*mastersi*, n. sp.
19.	Elytral apices subdentate	*howitti* Pasc.
	Elytral apices separately rounded	20
20.	Elytra with punctures and pustules	*monticola* Blkb.
	Elytra without punctures	21
21.	Punctures on head larger than those on pronotum	*puncticeps*, n. sp.
	Punctures on head smaller than those on pronotum	*puncticollis* Pasc.

In the above I have not utilized the coloured maculae, since these pubescent areas are subject to abrasion and discoloration (*vide* Pascoe's note under *aethiops*); but in *armitagei*, *aethiops*, *torridus* and *tricolor* there is a white spot near the middle of each elytron in fresh examples. *A. macleayi*, *maculatus*, *approximatus* and *barretti* have pale pubescent spots while *luciae* has an oblique line of pale pubescence behind the shoulder.

Microtragus Pasc.

Journ. Ent., 1865, p. 360.

The genus *Microtragus* was first used in 1846 by White (App. to "Stokes' Discoveries", Vol. i, p. 511) for the reception of *M. senex* White, without any definition or description of the generic characters. This omission was supplied nearly twenty years later by Pascoe when describing *M. arachne*, "the nearest ally to *M. senex*". White only noted the likeness to *Ceraegidion*, while Pascoe more accurately notes the extraordinary resemblance to the Amycterinae (now

Phalidurinae) group of weevils, a resemblance not only shown in the spinose armature and general facies, but in the clothing of "short, flat scales as in the Curculionidae" in certain species, "but in *M. arachne* the scales are narrower and longer, scarcely differing from true hairs".

This resemblance to the Phalidurinae is associated with a similarity of habit, the species being generally found, as with *Athemistus*, on the ground, under logs or other shelter. Personally I have taken only two species, *M. luctuosus* Shuck., and *M. bimaculatus*, n. sp., the former near Rockhampton, the latter at Kuranda and a variety at Tambourine Mountain, Queensland. In all cases these were found under dead Eucalyptus boughs on the ground—a well known covert for the Phalidurinae.

I have before me 130 examples, thanks to the loan of specimens compared with types, from the British Museum (also notes from Mr. K. G. Blair on certain uniques) together with long series from the Australian Museums. I am thus able to supplement the information given by Lea in his valuable tabulation and revision of the group (*Trans. Roy. Soc. S. Aust.*, 1917, pp. 619-625).

The genus forms one of the most interesting and perplexing groups of beetles that I have ever tried to systematize, and is of special interest to the student of evolution in the wide variations of many of the species. These variations make it extremely difficult to separate what may appear from individual examples to be clearly different species, owing to the number of intermediate forms that seem to link up such species. These are quite in accord with Darwin's law of variation being related to wide distribution, a distribution given in more detail later. Lea has noted the sexual character of the tubercles on the hind coxae of the ♂, besides the wider terminal segment of the palpi; both characters existing to a greater or less degree in all the species examined. *Microtragus* is clearly separated from *Athemistus* by (1) the approximate antennae, (2) the presence of two basal elytral spines.

The genus is separable into two distinct groups:—

A. Species with subscalose clothing, pronotum bispinose.

B. Species having long erect hair, pronotum quadrispinose.

The species that fall under B. are all from the subcoastal regions of Queensland and are comparatively easy to classify; the chief difficulty being the tendency to abrasion of clothing. Thus of *M. quadrimaculatus* Blkb., the description begins "Setis erectis sparsim vestitus", but an example from the South Australian Museum shows this only in a minor degree. Again Lea says of *basalis* "the long hairs are fairly numerous on the face and pronotum but on the elytra they are confined to the vicinity of the tubercles". A ♂ (Mackay) and ♀ (Endeavour R.) show a moderately thick clothing of long hair on the whole upper surface in one example. If my determination of this species be correct, as I think it is, the extra basal tubercle on the elytra near the side is much smaller than the discal, and in the ♀ example is not very evident.

Group A. is so much more difficult that I found it necessary to arrange my series into preliminary groups:—

(1) *luctuosus* Shuck. and vars. (2) *mormon* Pasc. and vars. (3) *senex* White. (4) *maculatus* Blkb. (5) *arachne* Pasc. (6) *eremita* Pasc. (7) *sticticus* Pasc. (8) *junctus* Blkb.

M. luctuosus Shuck. is generally easily identified. It has very much the *Acantholophus* facies, the lateral row of spines being very jagged and uneven. The Rockhampton district seems to be its centre, whence it extends northward to

Herberton and south into New South Wales. I took it near Yeppoon (Q.) and Mr. Denquet has taken it at Armidale (N. S. Wales). In size it is 12-18 mm. long.

M. mormon Pasc. is the largest and smoothest of the genus, having the discal costae entire and sub-parallel. Its region is chiefly South Australia and north-west Victoria, but the variety *albidus* Blkb., occurs in Western Australia. Size 19-22 mm. long.

Var. *M. waterhousei* Pasc.—The type is unique in the British Museum. Mr. Blair writes: "It may be only a form of *mormon*, but costae are more strongly crenulate, lateral costa does not approach tip so nearly . . . . apices of elytra strongly divergent, but not quite symmetrical so perhaps abnormal".

M. assimilis Blkb.—Type unique. Mr. Blair writes: "= *mormon* Pasc., colour more tawny and punctures on elytral intervals sparser".

M. albidus Blkb.—Type unique. "= *mormon* Pasc., colour rather more varied, punctures very similar to *mormon*, but nothing like *senex*".

M. senex White.—Typical examples of this are the smallest and most tapering at apex of group A.; in size 10-13 mm. long; the pronotum with rather close, and regular round, deep punctures; colour black or brown with white or ashy markings, these in general consisting of small, irregular lateral patches on pronotum, on the elytra a basal fascia, irregular markings on disc and sides of apical declivity (*vide* White's fig.). The discal and lateral costae appear as the boundary of separate elevations, the former entire, the latter sometimes a little crenulate, and quite devoid of elevated tufts, the large, sparse punctures produce short black setae which show up distinctly on the pale areas. Examples from Roebuck Bay, Derby and Kimberley Downs (N.W.A.), MacDonnell Ranges, Tennant Creek and Finke River (Central Australia), Ooldea and South Australia.

M. maculatus Blkb.—Cotype (label in Blackburn's handwriting) in National Museum is before me, from Alice Springs (Central Australia), also examples from Hermannsburg (C.A.) and Ooldea. The colours are more diffused and blotchy, but this must clearly be regarded as a variety of *senex* White. Size up to 18 mm. long.

M. arachne Pasc.—An example compared with type from the British Museum, labelled W.A., 15 × 5 mm., is not unlike *senex* in its pronotal sculpture and in general colouration, but the darker markings of the elytra appear chiefly in patches which tend to become setose tufts, more or less regularly placed on the discal costae, less raised on the lateral costae. I, hesitatingly, separate this from *senex* White by the raised tufts. Examples from Cue, Geraldton, Condon, Lander Creek (C.A.), Anthony's Lagoon (N.T.).

The variety mentioned by Lea (under *arachne* Pasc.) taken by Mr. H. W. Brown at Lake Austin and Southern Cross (also Cue, H.J.C.) in Western Australia is very puzzling and would seem to provide a link between *mormon* and *arachne*. Of large size (specimens before me 19-21 mm. long), colour somewhat as in *albidus* Blkb., the sculpture very varied, some containing the typical sculpture of *sticticus* Pasc. (the suture and costae having small elevated setose tufts irregularly placed) while in other examples, clearly conspecific, the tufts are absent and the costae little raised. The pustulose-punctate pronotum, without smooth medial area, the (sometimes) setose elytra with converging discal costae, separate it from *mormon* and place it near *sticticus* Pasc. It is possible that the unique *albidus* Blkb. may be a form of this. If so, Lea's synonymy would be justified. But for the doubt as to its kindred with *albidus* and the many divergent variations in this group I should have considered this a distinct species.

M. sticticus Pasc.—An example compared with type from the British Museum is labelled "N. Holl. N.E. Coast" and is 16 × 6 mm. It is almost a unicolorous dark grey, the pronotum much as in *arachne*, the dorsal elytral area is abraded, showing a coarsely punctate surface (seen in many other examples). The costae are as in *arachne*, the tufts thereon more sparse (8 on suture, 3 or 4 on each costa). Variations of this in size from 10-16 mm. long and varying in clothing according to the extent of abrasion, colour from grey to mud-colour, but always showing the tufted costae, are found in the series examined from Peak Downs, Cloncurry, Longreach, Endeavour River and N. S. Wales. Also recorded from Narrabri (N.S.W.) by Blackburn.

M. eremita Pasc.—Type unique. Mr. Blair says: "I cannot match. I send a specimen from Alexandria (N.T.) something like it. In shape and sculpture it resembles some of the specimens from Hermannsburg (*vide supra*, under *maculatus*), but colour is uniformly dirty earthy-brown with tufts of darker hair on dorsal costa, also less marked along suture and lateral costa".

M. junctus Blkb.—Type unique. Mr. Blair writes: "Comes near *eremita* but elytra more convex along suture, dorsal costae more elevated, *almost* convergent behind. Type very earthy, almost unicolorous".

Specimens from MacDonnell Ranges and the Northern Territory correspond with *eremita*—qua description—and amongst my series are forms that apply to *junctus*. Amongst these are several that show more than glimpses of the typical *arachne* colour scheme, which is perhaps a deciding factor pointing to inclusion of these three names under *arachne*. The very unusually wide distribution of this ground longicorn may be noted as extending from northern New South Wales through Central (not coastal) and North Queensland, the Northern Territory, Central Australia, North-west and Western Australia to South Australia.

My tabulation of the species is thus as follows with the understanding that it is applicable to more or less normal examples:—

Group *A*. Species with sub-scalose clothing. Pronotum bi-spinose.

1. Each elytron with two rows of isolated tubercles .... *luctuosus* Shuck.
   Each elytron more or less costate 2
2. Discal costae widely separate behind, elytra non-setose .... *mormon* Pasc.
   Discal costae converging behind, elytra scalose-setose 3
3. Costae entire, without tufts raised above general surface ...... *senex* White
   Costae (and suture) with evident setose tufts .... *arachne* Pasc.

Group *B*. Species with long erect hair, pronotum quadrispinose.

1. Concolorous .... *basalis* Lea
   Elytra with pale markings 2
2. Pale markings forming two fasciae .... *bifasciatus* Lea
   Pale markings forming patches 3
3. Elytra with four pale areas .... *quadrimaculatus* Blkb.
   Elytra with two pale areas 4
4. Elytra sparsely spinose .... *echinatus*, n. sp.
   Elytra with rows of small tubercles .... *bimaculatus*, n. sp.

The following is my view of the synonymy:—

luctuosus Shuck. = *amycteroides* (Stychus) Pasc. = *pascoei* Thoms. *mormon* Pasc. = (var. 1) *waterhousei* Pasc. = (var. 2) *albidus* Blkb. = *assimilis* Blkb. *senex* White = (var.) *maculatus* Blkb. *arachne* Pasc. = (var.) *eremita* Pasc. = (var.) *sticticus* Pasc. = *junctus* Blkb.

Microtragus echinatus, n. sp.

Chocolate-brown; palpi, antennae, legs and apex of elytra reddish; elytra with an oblique ashy marking near sides about half-way, everywhere with a sparse clothing of pale upright hair.

Head with large, sparse punctures (partly concealed by derm), without evident longitudinal impression; antennae more widely separated than usual: in the ♀ the interspace about the width of an eye as seen from behind, in the ♂ rather less; antennae not extending the length of the body. *Prothorax* convex, slightly wider in front than behind, with two conical, lateral spines, and two smaller (but pronounced) on disc in the same horizontal line with the lateral; disc coarsely, rather closely, punctate. *Scutellum* very small. *Elytra* elliptic-ovate, apices obliquely truncate, each with widely placed spinose tubercles more or less arranged in two rows (about five in each row) and a short irregular row near suture, and a large curved spine (directed backward) on each side of scutellum; interspaces deeply pitted with frequent coarse punctures, large at sides, smaller towards middle. *Prosternum* coarsely punctate, rest of underside impunctate. Dimensions: ♂, 11 × 4; ♀, 12 × 4·5 mm.

Habitat.—Queensland: Wide Bay (Australian and Macleay Museums), also Queensland (in National Museum).

Four examples, 2 ♂, 1 ♀, 1 sex doubtful, three bearing labels in the handwriting of the late Mr. G. Masters, the fourth in Melbourne Museum are before me. The species is very distinct from others of the genus by the combination of pilose clothing, 4-spinose pronotum and the large, distant spines of the elytra, which are not uniform in size and position in the three examples, those of the female being blunter and less elevated than in the male, while in one of the latter the spines invade the smooth apical area farther than in the other. The usual sexual distinction of the palpi occurs, the apical joint in ♂ triangular, in ♀ subulate. Its general facies is that of *Acantholophus* of the Phalidurinae. Type in Australian Museum.

MICROTRAGUS BIMACULATUS, n. sp.

Dark chocolate-brown; squamose, with long erect pale hairs on whole upper surface, elytra with two large pale spots near middle, the base of antennal segments and apices of tibiae also pale.

Head sparsely pitted with large punctures, space between antennae in ♀ less than diameter of an eye, in ♂ this space less, concave between sockets, scarcely sulcate on front. *Prothorax* as wide as long, sides moderately and evenly rounded, about as wide at base as at apex, with two conical spines at sides, and three smaller spinose tubercles on disc, the middle one very small, disc coarsely, unevenly punctate. *Scutellum* small, transverse. *Elytra* ovate, apices subtruncate, with a strong basal spine and about five rows of small tubercles on each elytron, the tubercles rounded and close, becoming successively smaller towards sides; in three examples rows of punctures seen near suture and between the first two or three rows of tubercles; in the other two examples the sculpture quite concealed by derm. In all cases a row of large punctures at extreme border. Prosternum coarsely punctate, rest of underside apparently impunctate. *Dimensions*: ♂, 10-12 × 4-4·5 mm.; ♀, 13-15 × 5-6 mm.

Habitat.—Kuranda (H. J. Carter, in National Museum), Cairns (E. F. Bryant, in British Museum, also Dr. E. W. Ferguson), Endeavour R. (National Museum), Tambourine Mt. (H. J. Carter).

Nine examples, 4 ♂, 5 ♀, examined show a species of the *basalis-quadrimaculatus* type, but showing a relation with *Athemistus* in the more widely placed antennae and the rows of elytral tubercles. The sexual distinction of the palpi is very strong; the ♂ having widely triangular apical segment, the same in the ♀ being more or less subulate. There is also a small tubercle on the hind coxae of the ♂.

The two ♀ examples from Tambourine Mt., vary in having only a slight hairy clothing on the elytra. This is, however, probably due to the fact that they were taken during semi-tropical rains, and some abrasion has taken place. They were at first described as distinct, but with the variations of other species before me I cannot separate them from the more northern forms. Holotype ♂ in the National Museum. Allotype ♀ in the South Australian Museum.

SOMATIDIA AUSTRALIAE, n. sp.

Castaneous; elytron with dark arcuate fascia at apical third; antennae and legs testaceous, the former having apices of segments black; body clothed with fine pale recumbent pubescence besides sparse, long, upright hairs; those on the elytra being much longer than on head and pronotum. *Antennae* considerably longer than body. *Prothorax* convex, oval, sides evenly rounded, disc densely and finely punctate. *Elytra* convex and ovate, narrowing to a rather finely pointed apex; basal two-thirds having rows of large punctures; the suture and (at least) one longitudinal elevation lightly convex, the latter bearing a row of punctures more distant and smaller than the seriate punctures; apical third closely pubescent and apparently impunctate. *Dimensions*: 4 × 1·5 mm.

Habitat.—New South Wales: Illawarra (G. E. Bryant and H. J. Carter).

Mr. Bryant and I obtained a few examples under Eucalyptus bark at Stanwell Park in October, 1908. The species does not appear to fit any of the described species from New Zealand and Lord Howe Island, though nearest *S. olliffi* Lea from the latter region, from which it differs in the opaque, densely punctate pronotum, the seriate arrangement of the elytral punctures and the dark markings on the apical half.

Type in the National Museum.

Fam. Dryopidae.

HELMIS BARRETTI, n. sp.

Wide, subovate, convex, very nitid black above, tawny brown beneath; antennae, legs and tarsi red.

Head coarsely and closely punctate, antennae finer than usual. *Prothorax* very wide, widest near base, rather uniformly convex, apex subcircular, anterior angles very acutely produced and explanate, base feebly bisinuate, widest at basal third, thence obliquely converging to front, again arcuately narrowing near front angles, basal third narrowing without sinuation to the subobtuse hind angles; margins explanate throughout, with a closely knobbed convex border; disc finely, regularly, not densely, punctate, without transverse depression or medial line. *Scutellum* longitudinally ovate, very nitid and impunctate. *Elytra* of same width as prothorax at junction, soon arcuately widening at shoulder, thence very gradually widening to apical declivity; a horizontal margin throughout, extreme border (as in most species) finely serrate; striate-punctate with rows of moderately large punctures placed in shallow striae, intervals flat and apparently impunctate, both striae and punctures less distinct near suture, this region subgibbous behind the scutellum. Prosternum and abdomen coarsely punctate, mesosternum deeply excavate, metasternum laevigate; all save the medial area of underside with a close cloth-like derm. *Dimensions*: 3·5-4 × 1·6-1·8 mm. (approx.).

Habitat.—Barrington Tops, Beanbah Creek (C. Barrett).

Fourteen examples examined are in their wide form and subgibbous elytra near *H. quadriplagiata* Cart., and the Tasmanian *H. simsoni* Grouv., to the latter of which it has the nearest affinity. *H. simsoni*, however, has a more coarsely

punctured pronotum, the elytra with deeper striae and finer punctures. *H. barretti* is the most nitid of all the larger concolorous species. I have great pleasure in naming it after its discoverer the well-known Victorian naturalist Mr. Charles Barrett. Type in Coll. Carter.

VAR. H. BASALIS. One example, that I cannot otherwise distinguish from the rest, has a pale yellow marking at the base of the elytra, extending from the margins nearly to the suture.

N.B.—The male in this as in *H. maculata* has a clothing of coarse, red hair near the apex of the front tibiae. The females in all the species can generally be detected by a slightly protruding forked ovipositor.

HELMIS CUPREA, n. sp.

Rather narrowly ovate; coppery bronze, moderately nitid, antennae and tarsi testaceous, the apical segment of the former dark.

Head: Eyes large, not prominent, its surface, as also that of pronotum, minutely roughened or shagreened, without defined punctures. *Prothorax* rather wide, the middle part of apex circular, anterior angles produced and acute; base lightly bisinuate, posterior angles rectangular; sides arcuate, little narrowed from base to third anterior and forming a small sinuation at its junction with the more decidedly narrowed anterior part; margins very narrow, only explanate—and then slightly—near front angles; disc lobate; the anterior part slightly more convex than, and separated from, the posterior area by a wide transverse depression; this hinder part more densely shagreened and less nitid than the anterior lobe; a marked triangular impression on each side at base, half-way between scutellum and margin. *Scutellum* large and circular. *Elytra* moderately widened at shoulders, thence ovately widening to a little behind middle; margins scarcely explanate and nowhere perceptibly serrated; very finely striate-punctate, both striae and punctures only to be made out under a strong lens; intervals flat with minutely wrinkled surface. Underside with smooth, nude, medial area; lateral regions, also the femora beneath, clothed with tawny felt-like derm. *Dimensions*: 2 (+) × 1 mm. (approx.).

Habitat.—New South Wales: Gresford, Allyn River (C. Barrett).

A unique example of a distinct species forms another of my friend's captures in this district. I have compared it under a "binocular" with the type of *H. metallica* King, its nearest ally, and note the following distinctions. *H. metallica* is larger, of a darker bronze, wider behind, more convex; elytra more strongly striate-punctate; two elongate basal impressions on pronotum longer than with *cuprea*. This species (*cuprea*) is the most finely sculptured of all except *H. polita* King, in which the elytral series are quite differently arranged. Type in Coll. Carter.

HELMIS MACULATA, n. sp.

Elongate; subopaque black, elytra with four yellow spots situated on shoulders and apical declivities respectively, antennae and palpi red.

Head and pronotum finely and densely punctate, eyes large. *Prothorax* elongate, apex emarginate, base strongly bisinuate, sides very lightly arcuate, widest near base, thence obliquely narrowing to apex, more abruptly narrowing with a feeble sinuation to base, anterior angles subacute and explanate, posterior obtuse; disc very convex anteriorly, flattened posteriorly, without transverse depression or medial line, margins scarcely explanate except near front angles.

Scutellum subcircular, finely punctate. *Elytra* wider than prothorax at base, oblong, very slightly widened behind middle, with narrow horizontal margin; striate-punctate, the striae not very deep, the seriate punctures round and rather close, intervals flat, with transverse wrinkles and signs of short, sparse hairs here and there. Underside coarsely and sparsely punctate along the nude medial area, the punctures less obvious, but showing through the felt-like derm at sides. *Dimensions*: 3·5 × 1·5 mm. (approx.).

Habitat.—New South Wales: Eccleston (Allyn River) and Barrington Tops (C. Barrett).

Twenty examples, varying little in size, were taken by Mr. Barrett in January, 1926. The other similarly marked species are *H. tasmanica* Blkb., and *H. quadriplagiata* Cart. From the former it is separated by being about half the size, the absence of transverse depression on pronotum and much finer elytral sculpture; from the latter by its narrower form, much less convex elytra, its opaque surface, denser pronotal punctures and wrinkled elytra. The pale spots are smaller than on either species. Type in Coll. Carter.

Helmis purpurea, n. sp.

Elongate-ovate; nitid purple bronze, legs and antennae dark castaneous.

Head rather coarsely and distantly punctate, eyes large. *Prothorax* at apex little wider than head, anterior angles deflected, unseen from above, base lightly bisinuate, sides feebly arcuate widening to behind the middle, thence nearly straight to the subrectangular hind angles; margins narrowly explanate, disc divided into two lobes by a wide transverse sulcus having a triangular extension behind; the anterior lobe more convex and punctured, like the head; the posterior region less convex, more sparsely and finely punctate than the anterior lobe. *Scutellum* large, semicircular. *Elytra* lightly obovate, considerably wider than prothorax, widest at apical declivity, margins not explanate nor perceptibly serrate; striate-punctate, the seriate punctures moderately large, separated by a distance of a diameter of one; intervals flat save for evident transverse wrinkles, a few small punctures also discernible. *Prosternum* with sparse foveate punctures, rest of underside apparently impunctate. *Dimensions*: 2 (+) × 1 (−) mm.

Habitat.—New South Wales: Gresford, Allyn River (C. Barrett).

Another species captured by this observant naturalist of which four examples are before me. More elongate and convex than *cuprea*, the prothorax especially more convex and more deeply divided by the transverse sulcus; the elytral sculpture is much more defined, the seriate punctures larger. The colour is also different. Than *metallica* King it is also narrower and more convex, and of a brighter bronze (*metallica* is greenish-bronze), and is without the elongate sulci that extend from the basal foveae parallel to the margin for two-thirds of the length of pronotum in King's species, in which the elytral intervals, especially near sides, are decidedly convex.

Type in Coll. Carter.

Fam. Tenebrionidae.

Pseuduloma Fairm. I think that the species described as *Alphitobius torridus* Cart., belongs to this genus and should therefore be known as *Pseuduloma torrida* Cart.

Trichosaragus Blkb. The species described as *Saragus convexus* certainly belongs here and must be known as *Trichosaragus convexus* Cart. I have a second example from Broken Hill, N.S.W.

PLATYDEMA NIGROSUFFUSUM, n. sp.

Oblong-elliptic, depressed; above and below, also appendages, castaneous red except the base of head and large subapical area of elytra black.

Head and pronotum very finely and closely punctate (more finely than in *P. tetraspilotum* Hope), antennae rather long, extending beyond basal half of pronotum; segments subtriangular, successively widening from 3 to 10, 11 subcircular. *Prothorax* very transverse, widest slightly in front of middle, apex widely arcuate, base bisinuate, sides moderately rounded, anterior angles rather widely rounded off, posterior obtuse; disc rather flat and uniformly punctate, basal foveae well marked. *Scutellum* triangular with blunted angles. *Elytra* as wide as prothorax at base, subparallel (in one example very lightly elliptically widened); striate-punctate with rather large punctures placed in impressed striae, intervals lightly convex (striae and intervals much as in *P. tetraspilotum*), intervals minutely punctate, underside closely punctate. *Dimensions*: 4-4·5 × 1·5 mm.

Habitat.—Bogan River, N.S.W. (Mr. J. Armstrong) and Lake Hattah, Victoria (Mr. C. Oke).

A very distinct species, larger and wider than *P. tetraspilotum* Hope, from which it differs, besides in colour, in wider prothorax, larger seriate punctures and the minute but distinct punctures of the elytral intervals. The black elytral mark extends over about two-thirds of the hinder area, leaving the extreme apex red, and having a somewhat undefined anterior limit. From *P. pascoei* Macl. (= *victoriense* Blkb.) also from *P. rufibase* Cart., it is easily distinguished by its red and more transverse pronotum, more parallel and depressed form.

Holotype in Coll. Carter, paratype in Coll. Oke.

DOCALIS ELONGATUS, n. sp.

Narrowly elongate; opaque brown, with white scalose pubescence, somewhat sparse and irregular on elytra, more dense on head and the lateral borders of pronotum.

Head very similar in structure to that of *D. funerosus* Hope, the canthus produced to the base of the eye, its surface—as that of the whole upper surface—with less and shorter hair; antennae of similar proportions but narrower than in Hope's species, without coarse hairs. *Prothorax* subquadrate, little wider than head, rather wider in front than behind, anterior angles subrectangular, the posterior rounded off; disc rather flat, finely shagreened, short bristly hairs showing at margins. *Elytra* wider than prothorax and more than twice as long (about 9 : 4), finely striate-punctate, the striae sometimes obscured by derm, some intervals towards sides feebly raised and a few elongate feebly raised impressions near suture; underside minutely punctate and in part clothed with white scales; tarsi short. *Dimensions*: 6-7 × 2 mm.

Habitat.—Western Australia: King George's Sound (Macleay Museum, 2 exs.); Australia, Sharp Coll. (in British Museum, 1 ex.).

Three examples examined show a species easily separated from its only congener by its much longer form and different sculpture, Hope's species having the suture and alternate intervals of elytra evenly subcostate. Its general colour is more dingy than that of *funerosus*, with the bristly clothing much less in evidence, though this may be due to abrasion. Type in Macleay Museum.

MESOMORPHUS MERIDIANUS, n. sp.

Shortly ovate; subnitid brown, antennae and tarsi reddish, upper surface with a sparse clothing of fawn-coloured setae and squamose derm.

Head: Sculpture concealed by hair, clypeus with semicircular excision, canthus narrow extending to the base of eye, antennae moderately long for the genus, the segments narrower than in *M. villiger* Blanch., 8-10 transverse, 11 ovate. *Prothorax* transverse, apex arcuate-emarginate, base bisinuate, anterior angles rounded off, posterior obtuse, widest at middle, sides evenly rounded without sinuation; extreme border feebly reflexed, slightly concave within this, disc finely, densely, cellulose-punctate, the sculpture obscured by squamose clothing. *Scutellum* large, transversely oval. *Elytra* not wider than prothorax at base, soon diverging, widest behind middle; striate-punctate, striae well impressed, the seriate punctures rather large and regular; intervals flat, of uniform width, transversely wrinkled and clothed with recumbent setae, forming biseriate rows on each of the first four intervals. *Prosternum* finely granulose, the rest of underside rather closely and finely punctate, much more finely so than in *M. villiger* Blanch. *Dimensions*: 6-6·5 × 2·5 mm.

Habitat.—South Australia: Port Lincoln and Port Augusta.

Two examples in the British Museum and one in the Macleay Museum, Sydney, are nearest to *M. villiger* Blanch. in general form, but the species differs as follows:

M. meridianus.	*M. villiger* Blanch.
Size smaller	larger
Ground colour brown	nearly black
Punctures above and below finer	coarser
Humeri rounded	angulate
Elytral intervals (mainly) biseriate-setose	triseriate-setose

Type in British Museum.

ULODES TUBERCULATUS, n. sp.

Convex, ovate; dark brown variegated with fawn colour; clothed with stiff scale-like hairs of a reddish colour.

Head triangular, eyes round and prominent, palpi with apical segment oval, antennae moniliform and bristled, 1 slightly larger than 2, subspherical, 3-6 equal and transverse, rest wanting. *Prothorax*: Apex with discal part strongly and circularly elevated, the wide foliate parts obliquely elevated, produced and acute-angled; base lightly bisinuate, lateral margins widely foliate and obliquely raised forming wing-like and angulate lobes, subacutely angled at middle, thence converging obliquely to the front and arcuately to the rectangular hind angles; the foliation of a pale fawn colour and fringed at margin with hairs; disc uneven and reddish, its front margin black, a short transverse ridge behind middle. *Scutellum* large, round and convex. *Elytra* convex and widely ovate, mottled in colour, much wider than prothorax at base, shoulders squarely rounded and gibbous, with six well raised subconical humps, four symmetrically placed on disc, two wider apart than these on apical declivity, the bristly clothing more evident on raised area and at sides. Underside chocolate-brown, with short scalose hair; mesosternum short, fore coxae globose, the structure generally very similar to that of *U. verrucosus* Er.; tibiae with alternate rings of dark and pale clothing; claw joint of tarsi red, as long as the rest combined on posterior feet. *Dimensions*: 3·6 × 2 (+) mm.

Habitat.—Queensland: Tambourine Mountain (H. Hacker).

An interesting addition to the small group in which I place it has been sent by that keen entomologist, Mr. Hacker. Its convex form and curiously shaped prothorax show a link between the Ulodinae and Bolitophaginae that may be of generic importance; but the structure of its under-surface and its clothing are very like *U. verrucosus* Er., as also the antennae to joint six. Until further material is available it may be placed under *Ulodes*.

Unique type in the Queensland Museum.

NYCTOZOILUS MACLEAYI, n. sp. Text-fig. 5.

Ovate, convex; subopaque black, antennae and tarsi reddish-brown, the latter sparsely tomentose.

Head and *pronotum* very finely punctate, epistoma truncate, oblique at sides, undulately joining the antennal orbit; a short longitudinal furrow on extreme base of front; antennae having segment 3 almost as long as 4, 5, 6 combined, 8-11 transverse, 11 oval. *Prothorax* widest behind middle, wider at base than at apex, the latter arcuate-emarginate, anterior angles acute, sides arcuately diverging from apex, sinuate behind, base with discal part truncate, the hind angles acutely produced backward; margins a little thickened, round and reflexed, a wide concavity within, disc with a medial sulcus, fine on apical half, widening behind but not quite reaching base, a large rounded depression on each side near middle and a wide ill-defined transverse depression near base. *Scutellum* widely transverse, a triangular depression behind. *Elytra* obovate, apical declivity moderate, shoulders obsolete; each elytron with four crenulate costae besides the sutural costa, the fourth near margin subobsolete; with transverse costate reticulations, the intervals punctate; the usual lateral row of punctures subobsolete. Beneath minutely punctate and with feeble longitudinal strigae; pronotal intercoxal process with two well marked striae. *Dimensions*: 16-17 × 9-10 mm.

Habitat.—New South Wales: Monaro district (in the Macleay Museum).

A distinct species that is nearest to *N. reticulatus* Bates (from an adjacent region), but easily distinguished by smaller size, finer pronotal punctures, the posterior angles of prothorax pointing hindwards, not outwards; the elytral reticulations less regular, with more than indications of the fourth costa (entirely wanting in *reticulatus*). Type in the Macleay Museum.

NYCTOZOILUS NICHOLSONI, n. sp.

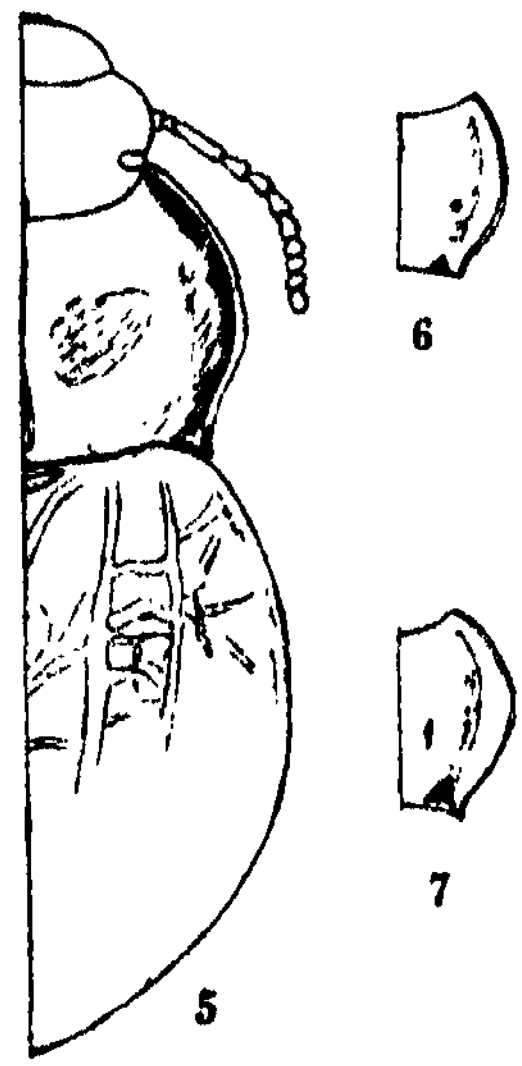
Differs from the preceding (*N. macleayi*) as follows: *Head* and *pronotum* more strongly and closely punctate, the antennal orbits less rounded and subcontinuous with the epistoma, the antennae longer and more robust; the pronotal margins more explanate, less concave within, the hinder sinuation of sides weaker, the posterior angles wider and less produced; the medial sulcus clearly defined, deeply impressed on basal half where it meets a well defined transverse basal depression. *Elytra* more parallel, very lightly widened behind; reticulate without any defined longitudinal costae; underside much more evidently punctate, the basal segments of abdomen strongly strigose; the pronotal intercoxal process narrower and nonstriate. *Dimensions*: 16 × 9 mm.

Habitat.—New South Wales: Mudgee (Macleay Museum).

Clearly distinct from *N. macleayi* by the differently shaped, noncostate elytra, which places it next to *N. irregularis* Blkb., in my table (These Proc., 1925, p. 236). It is separated from Blackburn's species of which the pronotum is described as

"marginibus lateralibus . . . haud recurvis . . . disco . . . utrinque ad medium fovea per magna *obsoleta* impresso et obsolete longitudinaliter canaliculato" while the prosternum is said to be "leviter 2-sulcato".

Type in the Macleay Museum.



5. *Nyctozoilus macleayi*. 6. *Cardiothorax consimilis*. 7. *C. australis*.

CARDIOTHORAX CONSIMILIS, n. sp. Text-fig. 6.

Nitid-bronze; head almost impunctate, frontal area scarcely impressed at base.

Prothorax: Apex arcuate, base subtruncate, widest in front of middle, sides rounded, sinuate before the subrectangular hind angles; lateral foliation horizontal and moderately wide, extreme border reflexed; disc with clearly cut medial sulcus and a small fovea near middle on each side of this. *Elytra* each with seven clearly defined sulci on disc with two narrower striae on sides; intervals rather flat, the third and fifth wider than the rest. Underside impunctate. *Dimensions*: 12-12·5 × 5 mm. (approx.).

Habitat.—New South Wales: Barrington (southern area of plateau) (Mr. John Hopson).

Mr. Hopson has recently (Feb., 1926) sent me three examples of a species which, though near, is distinct from its nearest allies *C. australis* Cart. (Text-fig. 7) and *C. macleayensis* Cart. From the former it is separated by (*a*) differently shaped prothorax (less prominent hind angles, wider border, etc.) (see fig. 6 and 7); (*b*) the elytra with 7 distinct sulci (in *australis* 8) while the intervals are flatter. *C. macleayensis* Cart. has only 6 distinct sulci on each elytron besides a differently shaped prothorax.

Type in Coll. Cart.

ADELIUM BASSI, n. sp.

Nitid-green or greenish-black, apical segments of antennae and tarsi reddish, robust, convex.

Head and pronotum coarsely punctate and slightly rugose, antennae having 3 longer than 4-5 combined. *Prothorax*: Anterior angles subacute, sides widest behind middle, with well defined sinuations near front and hind angles, the anterior sinuation the wider; posterior angles sharply subrectangular in one example (? ♂), slightly obtuse in the other (? ♀). *Elytra* striate-punctate, the seriate punctures as in *A. similatum* Germ., intervals widely convex and impunctate, the fifth narrowed and costiform on apical half and interrupted only by a single impressed puncture; intervals otherwise entire. Underside nitid and similar to that of *A. similatum* Germ. *Dimensions*: 17-18 × 8·5-9 mm.

Habitat.—King Island, Bass Straits (A. F. B. Hull).

An ally, possibly an extreme subspecies, of *A. similatum* Germ. var. *obesum* Pasc., which it resembles in size and form, but clearly differentiated by (*a*) the shape of prothorax (the marked sinuations emphasizing the angles) and by (*b*) the uninterrupted elytral intervals. Also distinguished from *A. alpicola* and its allies by the strongly convex elytral intervals. Two examples, probably the sexes, in the Australian Museum. The name, while honouring a great navigator, may also serve to suggest its habitat.

ADELIUM BREVE, n. sp.

Short, widely ovate; nitid dark bronze, antennae dark brown, 2nd segment red, tarsi reddish.

Head clearly, not densely, punctate; antennae moniliform, rather strongly widening outwards, 3 clearly shorter than 4·5 combined, 11 elongate. *Prothorax* strongly transverse, apex arcuate, base subtruncate, sides widely and evenly rounded, sinuate before the rectangular hind angles; anterior angles widely obtuse; margins without foliation or only indicated by a lunate impression; a fine, shining entire border at sides and base, disc clearly, irregularly punctate, the punctures moderately large; vague indications of a medial line, two round foveae behind middle. *Scutellum* triangular, punctate. *Elytra* wider than prothorax at base, shortly ovate, shoulders squarely rounded; striate-punctate, with ten deep, wide striae containing large, close punctures, crenulating the sides of interstices; intervals wide, themselves strongly punctate, convex towards apex, flattened anteriorly, 3rd and 5th wider than the rest. *Prosternum* rather strongly, abdomen finely, punctate; not strigose. *Dimensions*: 8 × 4 (+) mm.

Habitat.—Mount Kosciusko (near hostel, H. J. Carter).

I took three examples (one, at least, ♂) under planks near the golf links at the Hotel Kosciusko in Feb., 1926. It is one of the smallest species that, in its short, wide form, resembles certain *Brycopia*, e.g. *B. cheesmani*, but it is considerably larger and the eyes are not round. Though very distinct from other species, it is perhaps nearest *A. fergusoni*, from N. Queensland, which is, however, longer with a subcordate prothorax.

Type in Coll. Cart.

LICINOMA PLANATA, n. sp.

Elongate-ovate, depressed; dark, very nitid bronze, antennae fuscous, tibiae and tarsi reddish.

Head rather flat, finely punctate, antennae submoniliform, segment 3 little longer than 4, 7-11 considerably, successively enlarged, 11 twice as long and nearly twice as wide as 10. *Prothorax* depressed, widest at middle, apex arcuate, base subtruncate, sides widely and evenly rounded, without sinuation, all angles

rounded off, a thin reflexed laminate border at sides and base; disc with minute shallow punctures rather irregularly placed, without sign of medial line or distinct foveae. *Scutellum* transversely oval; a deep sutural depression behind it. *Elytra* wider than prothorax at base, elongate ovate; very finely striate-punctate, the fine striae with their rows of close and small round punctures very lightly impressed; intervals quite flat and impunctate. Underside impunctate and, like the upper surface, brilliantly nitid. *Dimensions*: 9 × 3·4 mm. (approx.).

Habitat.—New South Wales: Barrington Tops (Mr. John Hopson).

Mr. Hopson found the unique example under a board on the site of the University Camp of 1925. It is nearest to *L. nitidissima* Lea from which it is readily separated by flatter form, dark antennae, blunt pronotal angles, and much finer striae and seriate punctures. Type in Coll. Carter.

AMARYGMUS PUTEOLATUS, n. sp.

Oval, very convex; nitid coppery-brown above, black beneath, antennae, palpi, tarsi and underside of tibiae red, the tarsi flavo-setose.

Head: Clypeus punctate, eyes large and close, their interspace about the length of the second antennal segment, forehead triangularly widened behind eyes; antennae long and slender, 7-11 moderately widened. *Prothorax* widely transverse, widest at base thence arcuately narrowed to the front, apex feebly advanced at middle, more strongly so at the acute anterior angles, posterior angles obtuse; disc finely, distinctly but not uniformly punctate. *Scutellum* triangular and punctate. *Elytra* longitudinally and transversely convex, seriate-foveate, each with eight rows of large deep foveate punctures, besides a scutellary row of about 3 punctures and a lateral row crenulating the margin; intervals finely closely punctate; metasternum finely punctate, abdomen strigose; posterior tarsi with basal segment as long as the rest combined. *Dimensions*: 10 × 5 (+) mm.

Habitat.—New South Wales: Dorrigo and Queensland National Park (Illidge).

I have seen several examples of this very distinct species, but wrongly determined it as *porosus* Blkb., which is larger, differently coloured, less nitid and with smaller foveate punctures in its series. In *A. puteolatus* the foveae vary little in size, being almost as large near the suture as at the sides, and close enough to give an uneven aspect to the general surface. In general facies it is nearest to *A. bicolor* F., but the foveae are concolorous with the intervals, the outline is more elongate, the foveae smaller and more uniform in size and arrangement.

Type in the author's collection. There are also specimens in the State Department of Agriculture.

A. porosus Blkb. = *A. regius* Cart.—This synonymy was noted in my visit to the Natural History Museum in London in 1922, but was unfortunately not recorded in my Check List; the latter name must therefore be sunk.

Fam. Cistelidae.

CHROMOMOEA VARICORNIS, n. sp.

Elongate-navicular; head (mostly), knees, tarsi, most of antennae, prosternum, apex of abdomen black or dark piceous, the clypeus, basal segments of antennae, underside (mostly), prothorax and elytra yellow, the last darker at suture, sides and apex; legs (except knees) testaceous, 9th segment of antennae *white*. *Head* distinctly punctate, eyes widely separated, antennae with 3 longer than 4; 4-10 subconic, gradually but very lightly enlarging, 11 narrowly ovate-acuminate, about

as long as 10. *Prothorax* cylindric, longer than wide, feebly converging in front, as wide as head across eyes, with faint shallow punctures, a medial line on basal half widening behind. *Scutellum* rounded and concave. *Elytra* considerably wider than prothorax; striate-punctate, seriate punctures rather large and close except at base where the striae are narrower; intervals lightly convex and laevigate, the third wider and paler than the rest, forming an inconspicuous vitta. Pro- and metasternum finely and closely punctate, abdomen with more sparse and shallow punctures. *Dimensions*: 11 × 3 (+) mm.

Habitat.—Queensland: Innisfail (C. E. Simms).

A single specimen, probably female, examined is near *C. oculata* Cart. in general facies; but is easily separated by the curious antennal feature, mostly black with the 9th segment white.

Type in Queensland Museum.

TANYCHILUS AERATUS, n. sp.

Elongate-oblong; head, underside and legs bronzy-brown, pronotum and elytra nitid greenish-bronze, palpi, antennae and tarsi red.

Head very much as in *T. striatus* Newm., eyes approximate and antennae also very similar to that species. *Prothorax* subconic, brilliantly nitid, minutely and sparsely punctate. *Scutellum* large, subopaque, triangular with rounded sides, finely and closely punctate. *Elytra* more than four times as long as prothorax, subparallel for the greater part, slightly widening behind middle; striate-punctate, the seriate punctures mostly concealed except near base, intervals lightly convex, sparsely and finely punctate, whole underside glabrous, with a minute cellular surface most strongly shown on the metasternum and its episterna; apical segment of abdomen more nitid than the rest—due to the absence of this fine sculpture—and triangularly excised at apex. *Dimensions*: 19 × 6 (vix.) mm.

Habitat.—Queensland: Tambourine Mountain (A. Mussgrave and C. Geissmann).

A single male, taken by the above in October, 1924, is the only example I have seen of this fine species. It is easily distinguished by its brilliant colour and different undersurface from *striatus* Newm., *splendens* Bless., and *pulcher* Cart. As pointed out in my table (*Proc. Roy. Soc. Vict.*, 1915, p. 74) the two former species, apparently so alike, are clearly differentiated by the sculpture of the episterna; *T. aeratus* is also separable on this character alone, though nearer *striatus* than to *splendens*. In colour it is near that of the New Zealand *T. metallicus* White, which is but half the size, eyes distant, etc.

Type in the Australian Museum.

HYBRENIA SUBSTRIATA, n. sp.

Lightly obovate, black, nitid; palpi and tarsi piceous, upper surface sparsely, legs more densely clothed with black, short, upright hairs.

Head closely, strongly punctate; eyes rather close, interspace less than the length of 2nd antennal segment, antennae linear, 4-10 subequal in length, 11 pointed. *Prothorax* transverse, moderately convex, subrhomboidal, with front angles rounded and apex slightly advanced in middle, widest at base, posterior angles less than 90° from above, basal foveae forming a transverse depression, a shallow medial depression near base, disc closely and strongly but not confluently punctate, without medial line. *Scutellum* subcircular, punctate. *Elytra* slightly wider than prothorax at base, horizontal margin showing at medial compression;

widest behind middle; substriate, very fine striae only discernible on apical half, these displaced on basal half by faintly raised lines, surface otherwise flat, everywhere strongly punctate and faintly cross wrinkled. *Prosternum* nearly impunctate, mesosternum coarsely and sparsely, metasternum coarsely and densely punctate, abdomen with faint, shallow punctures and rugae, apical segment with longitudinal depression. *Dimensions*: 16 × 6 mm.

Habitat.—Queensland: Byfield, near Yeppoon (H. J. Carter).

Two examples were taken in October, 1924, both ♂, I think, and are nearest *pimeloides* Hope, *elongata* Macl., and *torrida* Cart., in facies and sculpture. From the first two it is distinguished by the much more closely punctured pronotum and more pilose surface; and from all three by its feeble striae—these not discernibly punctate. From *torrida* it is further separated by the less densely but more coarsely punctured pronotum. Type in Coll. Carter.

OMMATOPHORUS ILLIDGEI, n. sp.

Oblong; head and antennae piceous, rest of surface, legs and tarsi clear red, moderately clothed with subrecumbent red hair.

Head minutely punctate, eyes contiguous, antennae finer than in other species, segments narrowly triangular. *Prothorax* less convex than usual, widest at base, thence lightly narrowed to apex, disc pilose, and finely punctate, with a transverse depression near base. *Scutellum* triangular. *Elytra* very little wider than prothorax at base, sides parallel for the greater part, apices jointly rounded, very finely striate-punctate, intervals quite flat, each with a row of punctures of same size as those in striae, but more widely spaced. Underside minutely punctate. *Dimensions*: 5 × 2 mm.

Habitat.—Queensland: Brisbane (R. Illidge).

A single example, sent some time ago by the well known naturalist, is clearly distinct, being smaller, more finely sculptured and without the long upright hairs of the other two species, besides having colour differences. Type in Coll. Carter.

OMMATOPHORUS ATRIPES Cart. var. BICOLOR, n. var.—Mr. J. Armstrong has lately sent me 5 examples from the Bogan R. (N.S.W.) that I cannot separate from *O. atripes* except in having the elytra black (or nearly so), with a tendency to redness at the shoulders and suture.

REVISION OF AUSTRALIAN SYRPHIDAE (DIPTERA).

PART II, WITH A SUPPLEMENT TO PART I.

By E. W. FERGUSON, M.B., Ch.M., D.P.H.

(Sixteen Text-figures.)

[Read 27th October, 1926.]

Supplement to Part i.

Subfamily CERIOIDINAE.

An important paper on this subfamily by Shannon (*Ins. Ins. Mens.*, 13, 1925, p. 48-52) was unfortunately overlooked. In this paper the subfamily is divided into four genera according to the following key:

A1. Antennal process very elongate, distinctly longer than length of first antennal joint; a stigmatical cross-vein, or at least a distinct thickening present; metasternum membranous behind; hypopygium of male usually globose.
- B1. Abdomen slightly narrowed basally, anterior corners bright yellow; loop in third vein with a spur .... *Tenthredomyia*, n.g.
- B2. Abdomen distinctly constricted basally, anterior corners not bright yellow; third vein rarely with spur (present in *pleuralis* Coq.) .. *Monoceromyia* Shaw

A2. Antennifer very short or absent, rarely equalling half the length of first antennal joint; no stigmatical cross-vein or thickening present; abdomen constricted basally, without yellow spots at anterior corners; third vein with spur; hypopygium of male usually pointed apically.
- B3. Metasternum completely girdled with chitin .... *Polybiomyia*, n.g.
- B4. Metasternum membranous behind .... *Cerioides* Rod.

By this key the Australian species would fall into the three genera, *Tenthredomyia*, *Monoceromyia* and *Cerioides*, as follows: *ornatus*, *australis*, *opuntiae*, *platypus*, *alboseta*, *variabilis*, *apicalis* into *Tenthredomyia*; *macleayi*, *doddi*, *mastersi*, *facialis*, *subarmata* into *Monoceromyia* and *breviscapa* into *Cerioides*.

Not all the characters cited in the key under these genera are present in Australian species; thus the anterior corners of the abdomen are not bright yellow in several species and the spur to the loop in third vein is not usually (if ever) present.

In the same paper Shannon describes a new species *Tenthredomyia saundersi* from Sydney and gives note on a specimen identified as *T. australis* (Macq.) which is clearly the species I identified as *Cerioides ornatus* (Saunders). The new species (*saundersi*) is probably identical with my *Cerioides variabilis*, but the scutellum is stated to have the posterior half yellow, not the basal, as in *variabilis*, and the second abdominal segment has an apical yellow margin, which, though present in the female, I have not seen in any male in the series I have had under examination.

Subfamily ERISTALINAE.

ERISTALIS ARVORUM F.

Specimens of the species commented upon under this name in Part i were submitted to Dr. G. A. K. Marshall of the Imperial Bureau of Entomology. In reply Dr. Marshall writes: "The ♂ is probably *Eristalis arvorum* F., but abdomen is in bad condition; the ♀ is typically *suavissimus* Wlk.". While it is possible that both *E. arvorum* and *E. suavissimus* occur in Australia, I am not yet certain

that the specimens submitted do not belong to but one species. Unfortunately, males and females from the same locality are not available, and until further specimens come to hand it will be necessary to admit *E. arvorum* as well as *E. suavissimus* to the Australian list.

ERISTALIS COPIOSUS Walker.

This species proves to be identical with *E. sinuatus* Thoms. (= *decorus* Macq.) from comparison of a specimen with the type in the British Museum.

Subfamily MICRODONTINAE.

MICRODON VITTATUS Macq.

Paragus (?) *pachypus* Bigot (1884) should be added to the synonymy of this species. Dr. Guy Marshall in a letter stated that the type of *Microdon* (*Paragus*) *pachypus* Bigot is in the British Museum. Bigot's species was unknown to me and I had not thought of the possibility of it being a *Microdon*; the description, however, agrees perfectly with *M. vittatus* Macq.

MICRODON CHALYBEUS Ferg.

A specimen (♀) from Cradle Mountain, Tasmania, is in A. L. Tonnoir's collection. The specimen is smaller than usual, but otherwise conforms to mainland specimens.

MICRODON MODESTUS Ferg.

A specimen (♂) is in the National Museum, from Georgetown, Tasmania (C. E. Cole, 4.11.17). This record extends the distribution of the species to Tasmania.

MICRODON NIGROMARGINALIS C. and B.

The description of the puparium was unfortunately based on a specimen that was partly coated with mud and this coating was thicker than was realized. Additional specimens taken at the same place and time are now available and show that the granules are arranged in single series on undulating lines connected by cross lines, the whole forming a reticulum similar to that seen in the puparium of *M. variegatus*.

MICRODON MOESTUS, n. sp.

A black species with reddish-brown legs, black antennae with third joint upturned at tip as in *M. occidentalis* Ferg. Front black, very broad, practically parallel-sided, with whitish appressed pubescence, black around ocelli; face reddish-brown, about as wide as front, moderately densely clothed with white appressed pubescence; cheeks and posterior orbits with white pubescence. Antennae black, first joint short, cylindrical, third elongate, thickened and upturned at apex, the apical portion thinner and pointed, arista shorter than joint, lateral groove extending from below arista to half the length of joint; relative proportion of joints 7 : 3 : 17. Mesonotum black, slightly bronzy, pubescence scanty, dark, longer and pale at sides; scutellum rounded, not dentate, with scanty pubescence, arising from small granules and appearing dark from some directions, pale from others; pleural segments bronze-black, shiny, with mainly pale pubescence. Abdomen dark blackish-brown, each segment with a narrow patch of white pubescence at each side, along posterior margin, not reaching to midline nor to lateral border, but on apical segment forming a longitudinal patch on each side of midline at apex; some white pubescence at each side of base of second segment

and a patch at basolateral angles of each segment, pubescence otherwise short, appressed, dark. Venter dark brown, almost black. Legs reddish-brown, the coxae, trochanters and basal two-thirds of femora black, shining; tarsi infuscated. Wings grey, the veins brown; venation normal; halteres yellow.

Length, 9 mm.

Hab.—Tasmania, Hobart (C. E. Cole, 8.12.16).

Described from a single female in the National Museum, Melbourne. The species belongs to the group containing *M. chalybeus*, *M. occidentalis* and *M. dimorphon*, and in colour resembles the female of the latter species; the antennae are, however, different and closer to the shape seen in *M. occidentalis*.

MICRODON spp.

Text-figures are given showing the antennae of all the species of *Microdon*, with the exception of *M. hardyi* Ferg. and *M. pictipennis* Macq. I am indebted to Dr. I. M. Mackerras for the figures.

Location of Types of New Species.

The location of the types of the new species of Syrphidae was inadvertently not given in all cases. For convenience the location of all types so far described is given below.

Cerioides opuntiae	Macleay Museum
,, *platypus*	Australian Museum
,, *alboseta*	Australian Museum
,, *variabilis*	Australian Museum
,, *apicalis*	Australian Museum
,, *macleayi*	Macleay Museum
,, *doddi*	South Australian Museum
,, *facialis*	Macleay Museum
,, *mastersi*	Australian Museum
Eristalis conjunctus	♂, Macleay Museum ♀, National Museum
,, *kershawi*	National Museum
Helophilus terraereginae	South Australian Museum
Microdon alcicornis	Macleay Museum
,, *hardyi*	Coll. Hardy
,, *nicholsoni*	Macleay Museum
,, *macquariensis*	Macleay Museum
,, *waterhousei*	Australian Museum
,, *amabilis*	Queensland Museum
,, *dimorphon*	Macleay Museum
,, *occidentalis*	South Australian Museum
,, *chalybeus*	Coll. Hardy
,, *modestus*	Queensland Museum
,, *barringtonensis*	Macleay Museum
,, *moestus*	National Museum
,, *praetermissus*	South Australian Museum
Criorrhina multicolor	♂, Australian Museum ♀, South Australian Museum
,, *hackeri*	Queensland Museum
,, *fulva*	Macleay Museum
,, *rufocaudata*	Coll. Hardy

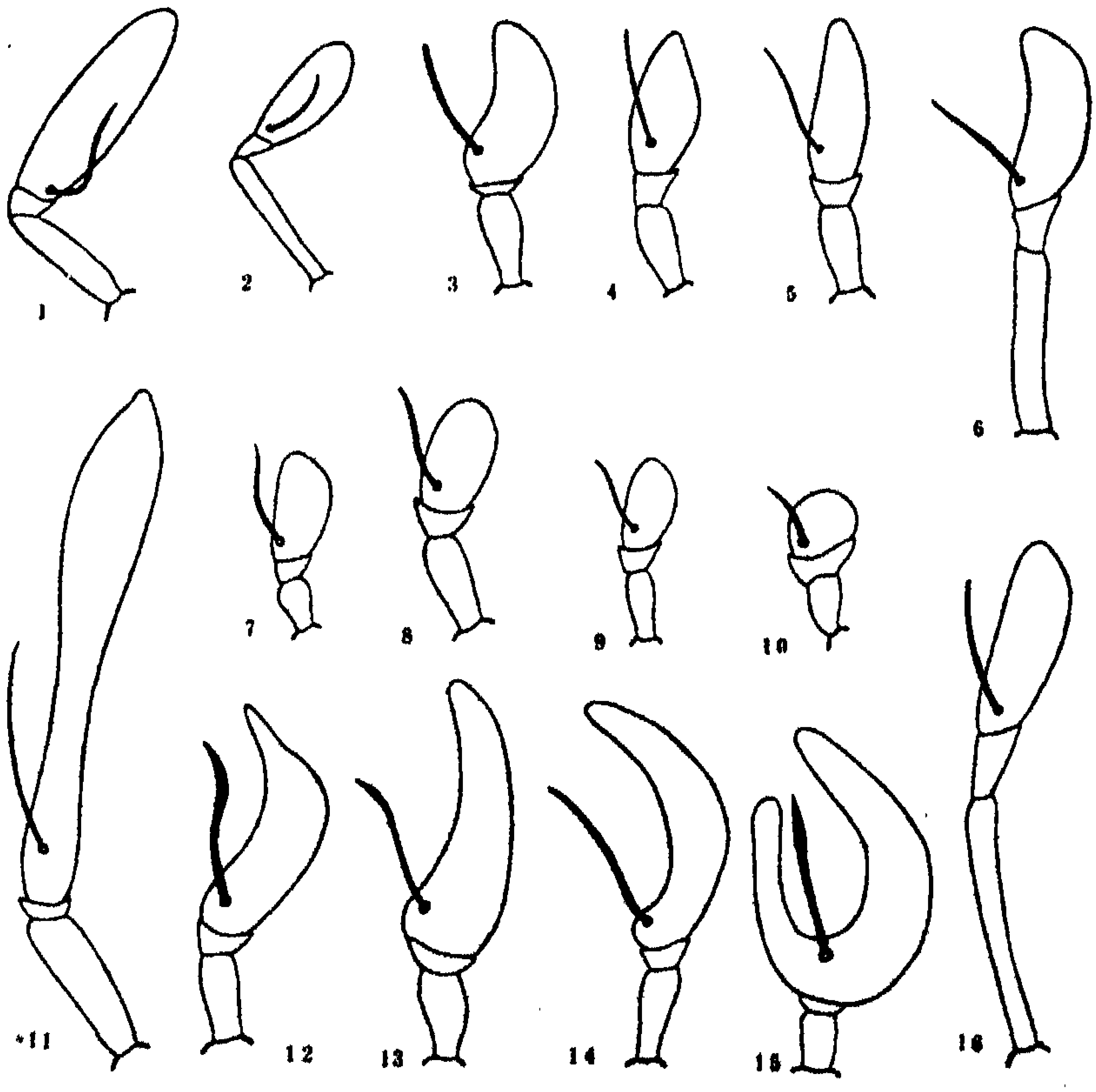
Xylota victoriensis	National Museum
„ *illucens*	National Museum
„ *iridescens*	Macleay Museum
Eumerus argyrogaster	Macleay Museum
„ *simplex*	National Museum
Graptomyza flavicollis	Macleay Museum
„ *doddi*	Macleay Museum
„ *plumifer*	Macleay Museum

Corrigenda to Part i.

p. 139, line 39, *for* fourth vein (R_{4+5}), *read* fourth vein (M_{1+2})

p. 161, line 26, *for* Meigen, 1922, *read* Meigen, 1822.

p. 168, lines 22 and 23, *delete* "as the western parts of the continent are not represented by any known species". This was written before the accession of the three species from Western Australia recorded in the paper and the excision of the statement was overlooked.



Text-figs. 1-16. *Microdon* spp., antennae.

1 *praetermissus*, 2 *amabilis*, 3 *dimorphon*, 4 *nigromarginalis*, 5 *brachycerus*, 6 *macquariensis*, 7 *modestus*, 8 *barringtonensis*, 9 *vittatus*, 10 *nicholsoni*, 11 *variegatus*, 12 *moestus*, 13 *chalybeus*, 14 *occidentalis*, 15 *alcicornis*, 16 *waterhousei*.

PART II.

Subfamily MILESIINAE.

Antennae generally pendent, arista dorsal, bare (in Australian genera). Frons prominent, bare or slightly pubescent; eyes generally bare, contiguous or approximate in the male, widely separated in the female; face usually bare. Hind femora generally dentate, spinose or serrate, often thickened. Cross-vein *r-m* at or beyond middle of median cell; R_{4+5} straight or feebly sinuous.

Brunetti, from whom the above is adapted, expresses himself as not quite convinced of the distinctness of the subfamily from the Eristalinae. The only distinction is of course the fact that R_{4+5} is not deeply looped, but this difference seems constant in the Australian species and these form a fairly homogeneous group with the possible exception of *Eumerus*. Concerning the latter, Brunetti remarks: "*Eumerus*, too, is somewhat abnormal, the venation and general appearance being very like those of the *Paragus*-group in Syrphinae". For the present the genus may be allowed to remain in the Milesiinae, and I would place here all the Australian genera in which *r-m* is at or beyond the middle of the median cell and which do not possess the special characters of the Eristalinae or Cerioidinae. This classification would include the species described by Hardy as *Chrysotoxum elongatum*. I have already given reasons for considering that the species is generically separable from *Chrysotoxum* and the only character in which it differs from other genera in the Milesiinae is the long antenna. Personally, I attach greater weight to the position of *r-m* than to the length of the antenna and have therefore placed the species in a new genus—*Hardimyia*—of the Milesiinae. Whether this course will be approved by dipterologists with a wider knowledge of the Syrphidae of the world remains to be seen. I am convinced at any rate of the necessity of removing the species from *Chrysotoxum*, and know of no genus to which it could with propriety be referred.

Deineches is distinguished by Hardy (1921, p. 18) from *Criorrhina* by the course of Cu_1 + 1st A being parallel to the wing margin. Though this is the case in the type species and in one or two other Australian species, there occurs at least one species in which the course of the conjoined vein is more or less direct to the margin and which cannot be separated from the type of *Deineches* on other structural characters. I have therefore followed Brunetti in sinking *Deineches* as a synonym of *Criorrhina*.

The species included under *Xylota* are somewhat diverse in type and are perhaps representative of more than one genus. I prefer, however, to place them all together. The remaining genus represented in Australia is *Syritta*, of which one native and at least one extralimital species occurs.

Specimens referable to either *Milesia* or *Meredon* have never been recorded.

Table of Genera.

1.	Antennae long, porrect	*Hardimyia*
	Antennae of only moderate length, pendent	2
2.	Apical portion of M_{1+2} outwardly angulate in middle	*Eumerus*
	Apical portion of M_{1+2} more or less straight	3
3.	Large robust species, generally with dense clothing	*Criorrhina*
	Narrow elongate species, bare or with but scanty clothing	4
4.	Cross vein *r-m* vertical	*Syritta*
	Cross vein *r-m* oblique	*Xylota*

CRIORRHINA.

Criorrhina Meigen, 1822, p. 236.—*Deineches* Walker, 1852, p. 227.—(For other synonymy see Brunetti, 1923, p. 280).

Head rather flattened, a little wider below the thorax (apart from pubescence of latter). Eyes bare, not quite touching in ♂, distinctly, though not widely separated in ♀; frons flattened, ending in an antennal prominence, below which the face is excavated distinctly, thence forming a large, stout snout, in which a central knob is moderately distinct. Antennae moderately long, third joint rounded or ovate, deeper than long; arista subbasal, bare. Thorax elongate-oval, rather arched, scutellum concolorous, both densely pubescent, without bristly hairs.

Abdomen varying in shape from nearly rounded to a narrow ellipse, densely pubescent. Legs rather strong, hind femora sometimes thickened, but normally without processes below; hind tibiae often curved, sometimes compressed. Wings with marginal cell widely open; *r-m* far beyond middle of median cell, very oblique—Brunetti, p. 280 (slightly modified).

Two Australian species have been described as belonging to this genus—*C. nudiventris* Macq. and *C. spadix* Hardy. I propose to sink *Deineches* under *Criorrhina*, the genotype of *Deineches* (*D. nigrofulva* Walker) being a synonym of *C. nudiventris*.

Hardy (1921, p. 18) maintains the latter genus as distinct on the character of the "veins that run parallel to the apical border of the wing; these veins merge into each other in a more or less unbroken line in *Deineches* whilst in *Criorrhina* they are separated by a space, thus breaking the line". He admits that "it is doubtful if this character is sufficient to justify generic separation". Brunetti (1923, p. 281) places *Deineches* as a synonym of *Criorrhina*, though the eyes are contiguous in the male.

The Australian species appear to form a fairly homogeneous group, though there are some differences in the head structure and in the course of the combined vein Cu_1 + 1st An. In *C. nudiventris* this runs parallel to the wing margin, while in *C. rufocaudata*, n. sp., which is structurally otherwise similar, the vein runs almost directly to the wing border.

Four new species are added to the genus in the present paper making a total of six.

The distribution is mainly southern and eastern; *C. hackeri* occurs in S. Queensland, *C. ruficaudata* in New South Wales, *C. multicolor* in New South Wales and Queensland, *C. fulva* in S. Australia and *C. spadix* in Tasmania, while *C. nudistylum* ranges from New South Wales into Tasmania.

Table of Species of Criorrhina.

1. First anal vein continued on beyond junction with Cu_1 in a direction subparallel to the hind wing border 2
   First anal vein not continued as above, the combined vein beyond the junction with Cu_1 running to the border more or less in the direction of the course of Cu_1 5
2. Iridescent metallic species, with dense golden pubescent bands on abdomen .... *C. multicolor*, n. sp.
   Non-metallic species, colours mainly black and yellow or fulvous 3
3. Mesonotum yellow with four black vittae .... *C. hackeri*, n. sp.
   Mesonotum largely dark, the colour obscured by dense yellow or greyish tomentum 4
4. Abdomen mainly black, bright fulvous at base (eyes contiguous in ♂) .... *C. nudiventris* Macq.
   Abdomen entirely fulvous; (eyes separated in ♂) .... *C. fulva*, n. sp.
5. Black species with broad reddish-orange tip to abdomen; wings with veins suffused with brown .... *C. rufocaudata*, n. sp.
   Reddish-brown species; wings with a broad brown band along anterior border .... *C. spadix* Hardy

CRIORRHINA MULTICOLOR, n. sp.

♂, ♀. Head as wide as thorax; front narrow in ♂, about five times as long as width at vertex, slightly narrowed in middle, thence widened out to antennal tubercle; slightly broader in ♀ at vertex, thence evenly and considerably widened anteriorly; densely clothed with bright golden tomentum with rather sparse golden hairs; ocellary triangle dark brown; antennal tubercle slightly produced, dark reddish-brown, densely clothed at base and sides with bright golden tomentum, somewhat lighter in colour than on front, the tomentum extending further on the tubercle in the ♂ than in the ♀; face with similar golden clothing, parafacials also densely clothed, appearing golden when viewed from in front, but brown when seen from side, the snout slightly produced, with a single slightly emarginate tubercle above and a more acute one on each side at free margin, the lateral portions below the parafacialia destitute of clothing, laevigate and of a deep violet-blue colour; cheeks small, clothed with dark grey tomentum; the occipital region with similar clothing. Antennae dark brown, almost black; first joint short, subcylindrical, second the length of first, but widened at apex, and laterally compressed, third joint broad, reniform, the arista dark brown, situated near base. Eyes bare.

Mesonotum iridescent green with purple reflections, with a pair of rather narrow median lines of deep black extending from anterior margin across suture to opposite wing roots, slightly divergent posteriorly, also with a similar dorso-central black vitta on each side, broad in front, but narrowing to a point posteriorly and extending to posterior margin, these vittae clothed with dense black pile; the humeral angle and lateral margin as far as wing root reddish-brown, the prominences clothed with bright golden pile; suture reddish-brown, not extending across midline; an oblong spot of golden tomentum on each side between humeral prominence and midline; pubescence light brown becoming black posteriorly, rather sparse, denser and bright golden on humeral and lateral prominences. Scutellum light yellow, becoming purplish-brown at the lateral corners, clothed with yellow pubescence. Pleural segments dark brown to black, for the most part dull, but mesopleuron with metallic greenish and purple reflections; a spot of dense golden pile in the upper portion of the sternopleuron; pubescence scanty, golden, a small tuft extending back from the mesopleuron; and a loose patch of pubescence on the upper mesepimeron. Abdomen with first visible segment bright metallic golden-green, duller at base, densely clothed with long bright golden pubescence; second segment metallic purple at base, the band of colour narrow in midline extending back on each side to beyond middle and densely clothed with bright gold pubescence, the rest of the segment black and clothed with dense black appressed pubescence; third segment dark metallic green with purple reflections, with black pubescence except for a broad apical band of dense golden pubescence extending forward on each side; fourth segment deep metallic green with black pubescence in centre and golden pubscence on each side; venter black with pale segmentations, the sternites with metallic reflections. Anterior and middle femora brown with purple reflections, the apices yellow; anterior tibiae yellow in basal, brown in apical half, anterior tarsi brown, the apical two joints pale yellow, the claws tipped with black; intermediate tibiae and tarsi all yellow; posterior femora very stout with a subapical ventral protuberance, more or less concealed by dense black pubescence, reddish-brown with purplish and greenish reflections, the under surface more violet and a deep violet patch in apical third on each side of ventral surface, pubescence black, the upper border with dense golden pubescence for basal two-thirds of length, the golden pubescence extending

on to upper portion of anterior surface; posterior tibiae strongly curved and somewhat thickened in apical third, yellow in basal half, reddish-brown in apical becoming darker at apex, with golden pubescence on basal half, black on apical; posterior tarsi with three basal segments dark brown with black pubescence and two apical segments yellow with golden pubescence, claws tipped with black. Wings with a broad band of brown along the anterior margin from base to apex where it is somewhat wider; venation as in *C. nudiventris*, but prolongation of 1 An. longer than in that species; *vena spuria* well marked. Calypters white with dark margin; halteres yellow.

Length, ♂ 14·5 mm.; ♀ 15 mm.

Holotype ♂, Eccleston (J. Hopson), 1.3.21; allotype ♀, Dorrigo (W. Heron); paratype ♀, Bunya Mts., Queensland (E. J. Dumigan).

The holotype was found by Mr. J. Hopson in the scrub at the head of the Allyn River, and the allotype was forwarded to the South Australian Museum by Mr. Heron of Dorrigo; the species appears to have a wide distribution along the highlands of the north coast of New South Wales, into Queensland.

The species agrees well in generic characters with *Criorrhina nudiventris* Macq., but differs entirely in the scheme of coloration. Holotype presented to Australian Museum, allotype in South Australian Museum.

CRIORRHINA HACKERI, n. sp.

A moderate sized yellow species with black lines on mesonotum, and black abdomen with yellow markings at base.

♀. Head yellow, front densely clothed with golden yellow tomentum, except on midline, which is linearly impressed, also with long golden pubescence, ocellary and vertical regions dark brown with long golden hairs, sides of front diverging anteriorly, at vertex about one-seventh, at base of antennal prominence a little less than two-fifths the head width, produced in front to a prominent conical antennal protuberance, which is pale yellowish-brown or testaceous, laevigate; face descending downwards and backwards from base of antennae, then produced forwards to oral margin, median knob absent, oral margin obliquely cut away at apex, not tuberculate, but feebly bifurcate with a moderately prominent projection on each side, the face densely golden tomentose except on median line and on ventral sides which are blackish; cheeks black, mostly bare, some greyish tomentum posteriorly; occiput with dense greyish-yellow tomentum and some pale pubescence on posterior orbits. Antennae short, the two basal segments yellowish-brown, the third black, subreniform, higher than long; arista long. Mesonotum yellow, densely clothed with yellow and bearing four black vittae, the two median vittae close together, narrow, mainly parallel, but convergent anteriorly and slightly thickened posteriorly, ending about midway between suture and scutellum; lateral vittae broken into two by the transverse suture, the anterior portion oval, obliquely-truncate posteriorly, the posterior portion elongate, tear-shaped, ending in a long point not quite reaching posterior margin, the vittae clothed with black tomentum; pubescence yellow, longer at sides and on postero-lateral ridge. Scutellum golden yellow with pale pubescent hairs, trapezoidal in shape, the lateroapical angles distinctly flanged. Pleural segments brown, mainly clothed with greyish tomentum, varying to brown around the periphery of the segments, pubescence pale; sternal segments black with grey pubescence.

Abdomen black, shiny, first segment brown with black apical band expanding at sides; second segment with a reddish-yellow mark on each side of base, not

meeting in midline, expanding laterally and continued along the lateral margin on to third segment, third segment with reddish-yellow mark on lateral margin extending from base, where it is somewhat wider, to the posterior quarter of the side; pubescence mainly dark, short and appressed, longer and yellow on the pale areas, some yellow hairs across middle of third segment and on each side of middle of fourth segment, lateral pubescence yellow from base to middle of fourth segment, thence black, longer at the base of second segment. Venter black, the second segment brownish, membranes connecting tergites and sternites grey, with a broad black patch opposite each segment. Legs clear yellow, the coxae, trochanters and apical third of posterior femora black, posterior tarsi, except tip of each segment and extreme tip of posterior tibiae, infuscate, the tarsi with golden pubescence beneath; posterior femora rather feebly thickened, with pale pubescence on basal two-thirds, black on apical, some closely set stiff bristles on under surface near apex. Wings grey suffused with brown across wing from tip of *Sc* to base of median cell, and along longitudinal veins especially marked at apex; this dark colour mainly due to fine microscopic pubescence. Venation as in genus, R_{4+5} rather strongly upturned at apex, *r-m* very oblique, situated well beyond middle of median cell, 1st Anal continued on beyond junction with Cu_1. Calypters yellow with yellow fringe; halteres reddish-yellow.

Length, 13 mm.

Hab.—Queensland: National Pk. (H. Hacker, December, 1921).

Described from a single female in the Queensland Museum. The species is most nearly allied to *C. multicolor*, but has entirely different coloration.

CRIORRHINA NUDIVENTRIS Macq.

Criorrhina nudiventris Macquart, 1846, p. 126, Pl. ii, fig. 9.—*Deineches nigrofulva* Walker, 1852, p. 228, Pl. 6, f. 7; Hardy, 1921, p. 18, Pl. 1, f. 3.

I believe from comparison of the descriptions and figures that the above synonymy is correct. Hardy failed to recognize Macquart's species, merely stating, "Under the name *Criorrhina nudiventris*, Macquart has described a species that probably does not belong to this genus". The name is attached to specimens in the National Museum, Melbourne, which are certainly the same as *Deineches nigrofulva* Walker, though I do not know by whom the determination was made.

I have already discussed my reasons for following Brunetti in sinking *Deineches* under *Criorrhina*, and a study of other Australian members of *Criorrhina* has confirmed me in the opinion that they are generically inseparable from one another, though differing in the characters of the contiguous or non-contiguous eyes and in the course of the 1st anal vein.

The present species is a very striking bright fulvous insect with the apical two-thirds of the abdomen black. It is closest in general appearance to *C. fulva*, n. sp., but that species has the eyes separate in the male.

Hab.—Victoria, Tasmania, New South Wales.

The species appears to be moderately common in the southern part of the continent. Hardy records it from New South Wales only, but most of the specimens I have seen were from Victoria or Tasmania; three specimens from Tasmania are in the South Australian Museum; they were taken at Hobart, Beaconsfield and Launceston. In New South Wales the species has not been recorded from north of the neighbourhood of Sydney. Mr. Froggatt has a specimen taken at Cordeaux Dam.

CRIORRHINA FULVA, n. sp.

A large reddish-brown species allied to *C. nudiventris* Macq.

♂. Eyes separated by one-eighth of head width at vertex and by approximately one-thirteenth at narrowest part anteriorly; ocellary region dark brown with fulvous hairs, small area in front of ocelli at narrowest part of front densely clothed with pale yellow tomentum; frontal triangle rather strongly produced, densely clothed with pale yellow tomentum with some pale yellow hairs, lunule brown, bare; face slightly retreating below antenna thence produced to oral margin with a well marked median knob, pale yellow, the median knob brown, vertical sides dark brown, upper portion of face with pale yellow tomentum continuous with tomentum of antennal tubercle, rest of face laevigate; oral margin produced obliquely downwards and forwards, the lower edge with a prominent projection on each side before apex; cheeks and mid-posterior orbits densely grey tomentose with grey pubescence. Antennae reddish-brown, third joint deeper than long, arista basal, dark brown. Mesonotum black, covered with grey tomentum, and with rather dense long yellow pubescence, humeral angle and posterolateral ridges reddish-brown. Scutellum reddish-brown with long dense yellow pubescence, apical margin rounded, with a somewhat obscure subapical transverse impression. Pleurae mainly black, yellowish-brown on mesopleuron, grey tomentose and with long pale yellow pubescence.

Abdomen reddish-fulvous with similarly coloured short depressed hairs, longer pale yellow pubescence present at sides, longest on second segment. Venter reddish-fulvous.

Legs reddish-fulvous with the tips of claws black, pubescence mainly pale yellow, but some short black setae present on undersurface of posterior femora; posterior femora greatly thickened and widened, ventral surface with a short obtuse subapical tubercle, posterior tibiae strongly bowed, a slight projection present on undersurface near base. Wings pale grey; venation as in *C. nudiventris*.

Length, 15 mm.

Hab.—South Australia, a single specimen in the Macleay Museum.

Described from a somewhat damaged specimen which yet appears sufficiently distinct to merit description. The species is allied to *C. nudiventris*, but differs in its generally paler colour, the concolorous abdomen, and in the dichoptic eyes: in *C. nudiventris* the eyes come together at a point anteriorly.

CRIORRHINA RUFOCAUDATA, n. sp.

A black species with reddish-orange apex to abdomen.

♀. Head black; front approximately one-eighth the head width at vertex, widening to about two-sevenths head width anteriorly; antennal prominence not very strongly marked, black, a band of golden tomentum across front at base of antennal prominence, sides of prominence with grey tomentum, pubescence golden yellow; face produced downwards and forwards from base of antennae to a low and rather inconspicuous central knob, thence to oral margin, black, densely clothed with grey tomentum, except on a bare triangular area on each side of mid-line and on the vertical sides; oral margins strongly cut away at apex with a prominent projection on each side; posterior orbits with silvery grey tomentum and pubescence. Antennae reddish-brown, the basal joints with whitish hairs above; third joint subovate, somewhat deeper than long, arista reddish-brown at base, becoming darker towards apex. Thorax black with obscure grey pruinescence forming two macules on each side along anterior margin, a pair of median

longitudinal vittae, and irregularly clothing posterolateral and posterior margins; suture grey tomentose; pubescence arising from small discrete granules, mainly dark with some grey hairs intermingled, along sides, and posteriorly longer and white. Scutellum distinctly transverse, convex, blackish-brown with a whitish flange-like apical border, the whole with long white pubescence. Pleurae black, grey pruinescent, pubescence grey to white. Abdomen black, the apical half of fourth segment broadly orange in middle, narrowed at sides, this portion clothed with reddish-orange recumbent pubescence, fifth segment retracted, reddish-orange; pubescence elsewhere black appressed with white pubescence at latero-basal angles, longer white silvery pubescence present at sides of second segment. Venter black. Legs black; anterior tarsi whitish, the metatarsus and second joint somewhat infuscate and showing black except at apex on under surface, a black patch also present on apical joint at base of claws; intermediate tarsi entirely whitish-yellow, posterior tarsi reddish-yellow; posterior femora greatly incrassate with a subapical flange-like projection from anteroventral border, tibiae strongly bowed; a fringe of dense black hairs along posteroventral border of posterior femora, pubescence elsewhere white. Wings greyish, microscopically pubescent, the longitudinal veins suffused with brown in outer half of wing. Calypters white with brown border and greyish fringe. Halteres pale yellow.

Length, 14 mm.

Hab.—N. S. Wales: Barrington Tops, 13-17 December, 1921 (G. Goldfinch).

In this species the course of 1st anal vein is directly continued to the wing margin. The species is, however, so closely allied to *Criorrhina nudiventris* in the structure of the face and posterior femora that I do not think it should be generically separated.

Criorrhina spadix Hardy.

Criorrhina spadix Hardy, 1921, p. 17, Pl. 1, fig. 5, 6 and 7.

The holotype of this species has been lodged by Hardy in the Australian Museum. The species is thoroughly distinct from the remaining members of the genus in Australia and should be readily recognized from the description and figure given by Hardy.

Hab.—Tasmania: Hobart (Hardy 1.2.17).

As the male only was known to Hardy, the following description of the female is given.

♀. Agrees with male in general coloration and characters; differs as follows: Eyes widely separated, the front evenly widened from ocellary region to antennal tubercle; central knob of face barely indicated, the whole front and face without golden tomentum, a little greyish tomentum along orbits, and on vertical sides of snout; posterior femora slender, not swollen, posterior tibiae only slightly bowed.

Length, 13 mm.

Described from a female labelled Tyenna, 12.12.17, C. E. Cole, in the National Museum, Melbourne, which had been identified by Hardy as this species. A second female from Magnet, Tasmania (Lea), is in my own collection.

The wings are described by Hardy as "brown along the anterior border, otherwise they are more or less hyaline and yellow at the base". In the females the brown colour is expanded in the middle along the cross-veins and the veins at the apex of the wing are also suffused with brown.

SYRITTA.

Syritta St. Fargeau Serville, 1825, p. 888.—(For other synonymy see Brunetti, 1923, p. 244).

Closely allied to *Xylota*, distinguished by *r-m* cross-vein which is placed at the middle of the discal cell and upright. Face with a central keel. Second segment of abdomen projecting back at sides, bearing a peculiar fringe of hairs at its most produced portion. Hind femora extremely incrassated, with short rigid spines beneath. (Brunetti, somewhat modified).

Two Australian species have been referred to this genus; in one case the species appears to be a native form; in the other case, an Oriental one whose range embraces Australia.

The Oriental species are apparently very variable and it seems doubtful from Brunetti's remarks whether they should not all be referred to but one species. The endemic Australian form (*S. hackeri*) certainly appears distinct from the Oriental species.

Life history.—*S. hackeri* has been bred from rotten banana stems; the other species probably also breed in rotting fruit and other vegetable refuse. *S. pipiens* L. lives in horse or cow dung (Brunetti, *l.c.*, p. 244).

The two species found in Australia may be distinguished as follows:

Size larger (11·5 mm.); pale markings on head and thorax bright yellow; with projection on under surface of hind tibiae .... *S. hackeri* Klocker

Size smaller (8 mm.); pale markings on head and thorax greyish-white; with hind tibiae evenly curved, without projection on ventral surface ...... *S. orientalis* Macq.

SYRITTA HACKERI Klocker.

Syritta hackeri Klocker, 1921, p. 59, Pl. x, fig. 4.

The ♂ only was known to Klocker; several specimens of both sexes are before me and show some difference in colouring and structure of the legs. In the female the posterior femora are black in colour, while the posterior tibiae practically entirely lack the flange-like projection from the ventral surface, which is present in the ♂ and well shown in Klocker's figure.

The species has been bred by the Agricultural Department from larvae found in rotting banana stems on the Tweed River.

Hab.—Queensland: Brisbane. New South Wales: Wollongbar.

*SYRITTA ORIENTALIS Macq.

Syritta orientalis Macq., 1842, p. 76.—*S. illucida*, Walker, 1860, p. 121. (For other synonymy see Brunetti, 1923, p. 246).

Klocker (1921, p. 60) records with some doubt the presence of this species in Australia under the name of *S. illucida* Walk. Brunetti (1923, p. 249 and footnote) sinks *S. illucida* as a synonym of *S. orientalis* from an examination of Walker's type.

The species is apparently variable in the coloration of both abdomen and posterior femora and the short series before me shows variation in these respects. Brunetti's description and remarks should be consulted as to these variations and as to the question of the distinction between this species and *L. pipiens* L.

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* Australian specimens are stated by Dr. G. A. K. Marshall to differ from both *S. orientalis* and *S. pipiens* in the unusual markings on the second abdominal segment and in the leg coloration. As the species varies in the colour of these parts in different specimens I prefer not to describe it as new at present.

All the specimens before me are decidedly smaller than those of *S. hackeri* and the yellow patches of the latter are more whitish in *S. orientalis*. The ♂ has the posterior tibiae simple.

Hab.—Queensland: Brisbane, Eidsvold, Gordonvale.

A specimen from Darwin, Northern Territory, probably represents a distinct species; it is smaller (5 mm.) and the posterior femora are less thickened, somewhat differently shaped and with a more conspicuous basal ventral tooth; the veins in the wings are pale. This last character suggests *S. luteinevris* de Meijere, but the smaller size and the dark brown, not black, posterior femora preclude me from identifying it with de Meijere's species in the absence of any details of the structure of the posterior femora.

XYLOTA.

For synonymy see Brunetti, 1923, p. 231.

Head generally slightly broader than thorax, eyes bare, contiguous in male, widely separated in female; face hollowed below the moderate antennal prominence, upper mouth edge distinctly produced, central knob absent; antennae with third joint rather large, round or oval, arista bare, subbasal. Thorax oblong, fairly arched; scutellum concolorous; both fairly pubescent. Abdomen narrow and much longer than thorax, rather flat, with nearly parallel sides. Legs strong, hind femora more or less thickened or lengthened, generally serrulate below, hind trochanters of male often with a process or spine below, hind tibiae more or less curved, sometimes ending in a distinct spur. Wings with the venation of the Milesiinae; cell R open; R_{4+5} nearly straight; *r-m* at or beyond middle of median cell, very oblique.

The above diagnosis, slightly modified from Brunetti, covers the Australian species, except that a facial knob is present in the male only of *X. illucens*, n. sp. The femoral structure varies somewhat in the different species; the hind femora are stout in *X. pleuralis* Kertesz and *X. victoriensis*, n. sp., and long and slender in *X. iridescens*, n. sp. The other two species are intermediate, in *X. flavitarsis* Macq. the posterior femora approximate to those of *X. pleuralis* and in *X. illucens* to those of *X. iridescens*.

Two Australian species have previously been placed in this genus. I propose to place here three additional species, two of them with a somewhat different facies from the other two, but apparently, from description, approximating to certain Indian species.

Distribution.—The genus is known only from the eastern portion of the continent. *X. pleuralis* occurs in Queensland and New South Wales. *X. victoriensis* is its representative in Victoria; *X. flavitarsis* appears to be most common in Victoria, but extends into New South Wales; *X. illucens* is known from New South Wales and Victoria, while *X. iridescens* is described from a single specimen from New South Wales.

Table of Species.

1. Dark species with thickened hind femora 2
   Yellowish species with comparatively slender hind femora 4
2. Thorax black, non-metallic, legs black, tarsi white .... *X. flavitarsis* Macq.
   Thorax metallic 3
3. Thorax brassy green with a prescutellar patch of golden pubescence, and golden pubescence on pleura; posterior femora all black .... *X. pleuralis* Kertesz.
   Thorax without pubescent patches, posterior femora ringed at base ....
   .... *X. victoriensis*, n. sp.

4. Thorax with golden tomentose stripes, abdomen with large translucent patch on each side of 2nd and 3rd segments .... *X. illucens*, n. sp.
Thorax with golden tomentose spots; abdomen with only a small yellow spot on each side on the second and third segments .... *X. iridescens*, n. sp.

XYLOTA PLEURALIS Kertesz.

Xylota pleuralis Kertesz, 1901, p. 413; *id.*, *Hardy*, 1921, p. 17.

Specimens agreeing with Kertesz's description are before me from Eccleston, New South Wales and Queensland.

The species is readily distinguished by the brassy green thorax with its dense bright golden pubescence and the similar patch of pubescence on the mesopleuron. There is no spinous process on the hind trochanters.

In a female from Brisbane, the eyes are separated by one-eighth of the head width and the front is black; the golden pubescent tufts are present on the dorsum and pleura and the posterior femora are black.

Hab.—N. S. Wales: Eccleston, Pt. Macquarie. Queensland: Brisbane, National Park.

XYLOTA FLAVITARSIS Macq.

Xylota flavitarsis Macquart, 1846, p. 134; *id.*, 1850, p. 146; *id.*, Hardy, 1921, p. 17.

The general dull black coloration and the pale creamy tarsi render this species readily recognizable. In the ♂ there is a long curved rod-like process arising from the under surface of the hind trochanters.

Hardy (*l.c.*) records this species from Tasmania and Victoria. Several specimens are before me from various localities in the latter State, and from the Blue Mountains, Eccleston and Toronto in New South Wales.

Hab.—Tasmania, Victoria, New South Wales.

XYLOTA VICTORIENSIS, n. sp.

A black species with brassy green thorax; allied to *X. pleuralis* Kertesz, but without pleural pubescence.

♀. Head black, front about one-fifth of head width at vertex, widening to approximately one-third of head width anteriorly, black, shining, with some sparse dark hairs, grey at sides anteriorly and brownish on vertex, antennal protuberance moderately prominent; face slightly retreating beneath antennae, thence produced to oral margin, the latter obliquely cut away at apex with a small projection on each side, densely clothed with pale yellow tomentum, vertical sides and cheeks black, some scanty grey hairs on cheeks and posterior orbits; antennae blackish-brown, third joint about as deep as long, arista basal, longer than joint.

Mesonotum brassy green, metallic, moderately densely clothed with a rather short erect golden pile; the humeral angles and posterolateral ridges black with faint blue sheen. Scutellum similar to mesonotum, but with only some scanty yellowish hairs. Pleurae black, with some scanty grey pubescence.

Abdomen black, with short black pubescence; some scanty white hairs on each side near base on third and fourth segments; lateral hairs whitish, longest at base of second segment. Venter black. Legs blackish-brown, anterior leg with extreme base of femora brownish and the extreme apex of femora and basal third of tibiae yellow, anterior tarsi pale brown, lighter beneath, the apex darker, intermediate legs similar but the yellow about knees is yellow-brown and less extensive; tarsal joint almost whitish with dark tips, the two apical joints dark; posterior femora strongly incrassate with some spinose setae along lower surface,

black with broad bright yellow band at extreme base, posterior tibiae bowed, tarsi dark brown. Wings hyaline, very slightly suffused with grey towards apex; venation as in genus.

Length, 9 mm.

Hab.—Victoria: Bendigo (L. B. Thorn). A single female in the National Museum, Melbourne.

While closely allied to *X. pleuralis* Kert., the present species differs in the absence of the golden pubescent prescutellar and pleural tufts, and in the banding on the posterior femora. The front is also wider than is the case in the female of *X. pleuralis* Kert.

XYLOTA ILLUCENS, n. sp.

A black and yellow species with striped thorax, and iridescent abdomen.

♂. Head testaceous yellow; eyes meeting for about one-sixth of distance from vertex to base of antennae, vertex and ocellary triangle black with long yellow pubescence, a small narrow triangle in front of ocelli golden tomentose; frontal triangle rather strongly produced, densely clothed with golden tomentum; face moderately strongly produced downwards, retreating below antennae, thence produced to oral margin with a marked central knob or hump, oral margin with a prominent projection on each side, densely yellow tomentose, except on midline and on vertical sides, the tomentum extending across middle line above the hump; general colour testaceous with a dark almost blackish mark on vertical sides near eye border; cheeks with scanty grey tomentum and some straggling grey pubescence; posterior orbits grey tomentose with fine scanty grey pubescence; eyes bare, equally faceted; antennae light reddish-brown, short, the third joint briefly ovate, arista long, dorsal, subbasal, bare. Mesonotum black with a rather narrow golden tomentose vitta on each side of the broad black median line; these vittae are divergent posteriorly, a second vitta on each side along lateral margin, only golden tomentose in front of suture, elsewhere more reddish-brown, a golden tomentose band connecting the vittae on each side and extending over humeral callus, but not crossing midline; pubescence rather scanty, long yellow; some longer yellow hairs present on posterolateral ridge; scutellum reddish-brown, lighter at apex, apical margin rounded with a narrow flattened border; pubescence long, scanty, yellow. Pleural segments mainly black, in places brownish, and feebly iridescent, with a prominent golden tomentose patch on mesopleuron and a smaller one on sternopleuron; pubescence scanty, yellow.

Abdomen elongate, distinctly narrower than mesonotum, flat, practically parallel-sided; first segment testaceous, second segment yellow testaceous with a dark brown broad median vitta gradually widening out from middle to embrace entire hind margin, lateral borders also dark brown; third segment shorter, similar, but yellow reduced to smaller patch on each side, extending slightly beyond middle, on both segments the yellow areas are translucent, practically transparent, and in certain lights iridescent, the brown lateral margins are markedly purple iridescent; fourth segment bluish-black, slightly iridescent, diluted with red along lateral margins and apex, the junction between the colours ill-defined, genital segments reddish-brown; pubescence short, scanty, dark brown, but yellow on the yellow areas; longer yellow pubescence present on sides of second segment. Venter yellow, translucent at base, black at apex.

Legs moderately long, light reddish-brown, coxae black, trochanters dark brown, the posterior black, apex of posterior tibiae with ill-defined blackish staining, pubescence short, yellow; posterior coxae with a short tooth on inner

posterior angle, posterior trochanters triangularly produced at apex; posterior femora slightly thickened with a group of black spinose setae on each side of ventral surface near apex; posterior tarsi feebly curved. Wings hyaline, the costal cell and extreme base pale yellow, a faint ill-defined brownish mark in anterior portion opposite inner end of median cell, a larger ill-defined faint brownish patch at apex, including greater portion of cell R_5; *r-m* very long and oblique, reaching *m-c* well beyond the middle; cell R_5 closed on wing margin. Calypters golden with golden fringe; halteres yellow.

♀ agrees with ♂; eyes separated; forehead with sides divergent anteriorly, at narrowest part about one-eighth total head width, black round ocelli, golden tomentose, except for a narrow median black line and the prominent laevigate reddish-brown antennal tubercle, the golden tomentum on face reduced to a short line at base on each side continuous along the orbits with golden tomentum of front; face without central hump. Abdomen rather broader.

Length, 13 mm.

Hab.—Victoria: Narracan (1-96, W.K., type and allotype). New South Wales: Barrington Tops, Feb., 1925 (University Zoological Expedition), two ♀ paratypes.

The Barrington Tops specimens have the dark wing markings somewhat more distinct, otherwise they do not differ from the Victorian specimens.

The species is, in coloration, quite unlike any other known Australian species and possibly is not ascribed to the correct genus. I fail to find characters—apart from coloration—that warrant generic separation, unless the presence of a central facial hump in the male is to be regarded as of generic importance. The species, judging from descriptions, most resembles certain Indian species placed by Brunetti under *Xylota*.

XYLOTA IRIDESCENS, n. sp.

A rather slender, reddish-brown, iridescent species, with pale tomentose spots on mesonotum and abdomen.

♀. Head yellow or reddish-brown; eyes separated by about one-sixth of head width, in narrowest part, front once and one-half times as wide anteriorly as at vertex, produced forwards into a strong conical projection, yellowish-brown, the vertex lighter, a median line and the antennal protuberance reddish-brown, pubescence scanty, yellowish-brown, a pair of golden tomentose spots in front of ocelli, a large pair at base of antennal protuberance extending along orbits on to sides of protuberance; face retreating below the antennae, then produced forwards to oral margin, the latter with a projection on each side, no central hump present, reddish-brown in centre, this colour reaching orbits on each side above, the remainder yellowish-brown, golden tomentum present on each side of antennal protuberance narrowed along orbits, and as a prominent vitta on each side extending from orbits to oral margin; cheeks yellow-brown; posterior orbits with golden tomentum; antennae yellowish-brown, short, the third joint moderately large, briefly ovate, arista long, bare; eyes bare.

Mesonotum reddish-brown with marked bluish-purple and violet iridescence; with well defined pale golden tomentose spots, situated as follows: a spot on each humeral angle, and a spot on each side on anterior margin between humeral angles and midline, a spot anterior to outer end of suture, about midway in position between the spots on humeral angles and anterior margin, a smaller spot on inner end of suture, a spot above and slightly behind wing root and a small ill-defined spot on posterior margin between lateral angle and midline; pubescence short, rather scanty, pale. Scutellum similar to mesonotum, strongly

iridescent, apical margin present, not very distinct. Pleurae reddish-brown, a golden tomentose spot on wing root, another on mesopleuron and a third on sternopleuron.

Abdomen elongate, almost parallel-sided, very slightly narrowed on second segment; first segment reddish-brown with dark central vitta, lateral margins and apex; second segment black with greenish iridescence, a pair of small ovate yellow spots near anterior margin; third segment similar greenish-black, the apex diluted with red, with a pair of smaller more rounded spots near base, somewhat more outwardly situated; fourth and fifth segments reddish-brown with greenish iridescence; genital segments black, extruded; all the segments laevigate, with few fine punctures and very short sparse pale pubescence; longer pale pubescence at sides, particularly of first and second segments. Venter greenish-black, laevigate, the two apical segments reddish-brown, second segment with sides yellowish.

Legs comparatively long and slender, reddish-yellow, the posterior tarsi dark brown, paler at apex, all claws black with reddish-yellow base; posterior femora long, not incrassate, a few reddish-yellow spinose setae on each side of ventral surface near apex; posterior trochanters triangularly produced on inner side of femora. Wings clear, veins black, a short black transverse bar at middle, not extending beyond *vena spuria*, a black cloud near apex extending from anterior margin to beyond R_{4+5}, not involving extreme apex; *r-m* very oblique, situated well beyond middle of median cell. Calypters white with brown margin. Halteres pale yellow.

Length, 13 mm.

Hab.—New South Wales: Toronto (Filmer). A single female which perhaps may not be correctly placed generically. The long thin legs are not in keeping with other Australian species of *Xylota*, but the species appears linked in this respect through *X. illucens*, in which the legs are intermediate in size.

HARDIMYIA, n.g.

Genotype, *Chrysotoxum elongatum* Hardy.

Head semicircular, eyes bare, contiguous in male for a short distance, the upper and anterior facets somewhat larger than the others, eyes widely separate in ♀; front produced anteriorly; face moderately strongly produced at mouth border, not concave beneath antennae, but slightly concave above oral margin, no facial hump present. Antennae elongate, porrect, first joint cylindrical, second joint more than twice the length of first, slightly widened to apex, third joint broader than second, but somewhat shorter, laterally compressed, arista dorsal, subbasal. Thorax oblongate. Abdomen elongate, slightly narrowed on second segment, rather flat above, the general shape much as in some species of *Xylota*. Posterior femora strongly incrassate in both sexes, the posterior tibiae bowed. Venation as in *Xylota*, but *r-m* cross-vein opposite middle of median cell and rather less oblique.

Apart from the antennae, this genus has all the appearance of a species of *Xylota*, and I regard the two genera as closely allied.

I have already (Part i) given my reasons for removing *Chrysotoxum elongatum* from the Chrysotoxinae; the character of the elongate antennae does not appear to me to outweigh the other characters, which definitely ally the species with the Milesiinae. Apart from the position of *r-m*, *Hardimyia* differs from *Chrysotoxum* in the shape of the abdomen and in the thickened posterior femora.

The venation is also different; M_{1+2} shows a distinct backward bend at the apex of the median cell and the oblique apical portion of the vein is distinctly sinuate and somewhat recurved at junction with R_{4+5}.

HARDIMYIA ELONGATA (Hardy).

Chrysotoxum elongatum Hardy, 1921, p. 13, Plate 1, fig. 1, 2.

In describing this species Hardy remarked that it probably did not belong to *Chrysotoxum*, but that it was placed there until its position could be ascertained more satisfactorily.

The sexes show some difference in coloration; in the ♂ there is a pair of large yellow spots on the second abdominal segment; these spots are absent in the ♀.

Hardy has recorded the species from a number of localities in Tasmania. Specimens are before me from Tasmania, Victoria, South Australia and New South Wales, but the species appears to be rare except in Tasmania.

EUMERUS Meigen.

Eumerus Meigen, 1822, p. 202.

Head broader than thorax; eyes more or less pubescent, sometimes almost bare, contiguous in male for a distance varying from a long space to little more than a point, sometimes very narrowly yet distinctly separated; wide apart in ♀; face rather flat, central knob absent. Antennae variable, generally short but large, third joint rounded or ovate, occasionally elongate, usually larger in ♀; arista bare, 3-jointed, placed before middle of joint. Thorax subquadrate, slightly arched, usually aeneous black with short pubescence; scutellum concolorous, the actual margin occasionally serrulate. Abdomen longer than wide, sides usually parallel or slightly widened about the middle; nearly always with three pairs of pale lunules; tip blunted in male, more pointed in female; pubescence short. Legs moderately strong, hind femora thickened, with short stout bristles below; hind tibiae usually slightly curved; hind metatarsi generally incrassate, sometimes widely dilatate in male, in some species the succeeding tarsal joints also dilated. Wings with cell R widely open, *r-m* cross-vein at or beyond middle of median cell; R_{4+5} often sinuous; M_{1+2} recurrent and strongly outwardly angulate in apical portion, the angle usually with a short appendix.

The above generic diagnosis is taken from Brunetti (1923), but is somewhat modified in the description of the venation.

Life History.—Two species—*E. strigatus* Fln. and *E. tuberculatus* Rond.—have been bred in Europe from onions and other bulbs and have become rather serious pests of narcissus in Great Britain. Little is known of the life history of Australian species, but two—including *E. aurifrons* Wied.—have been bred by H. Mann from prickly pear (*Opuntia* sp.). Dr. Bancroft bred one species—*E. peltatus* de Meijere—from fruit.

Two species have been described from Australia—*E. latipes* and *E. fulvicornis*. A third species, *E. transiens* Walker, does not belong to the genus, but to *Microdon*, and is a synonym of *M. vittatus*. Hardy (1921, p. 1) expressed the opinion that *Merodon muscaeformis* probably belonged to this genus; this is, I think, incorrect, as the description agrees well with *Psilota coerulea* Macquart.

In describing *E. marginatus* Grimshaw, from Honolulu, the author suggested that it might be an importation from Australia. This appears to be purely an assumption and no species agreeing with Grimshaw's description has been described or recorded from Australia.

Two extralimital species—*E. aurifrons* Wied. and *E. peltatus* de Meijere—occur also in Australia; one (*E. peltatus*) was described from New Guinea, the other (*E. aurifrons*) is widely distributed in the Oriental region. A third species —*E. obliquus* F.—has apparently been introduced.

Two new species are described in the present paper; most species are rare and represented by but one or two specimens. Several unidentified females are also before me, but it has not been considered justifiable to describe these.

Distribution.—While so little is known of the Australian species it is impossible to define the distribution; so far, however, specimens have been taken only on the eastern coastal districts including Tasmania and in Western Australia. At least two species—*latipes ?* and *macquarti*—occur in Tasmania; one—*simplex* —in Victoria; four species—*macquarti*, *latipes ?*, *simplex* and *obliquus*—in the neighbourhood of Sydney and three in Queensland—*aurifrons*, *peltatus*, and *argyrogaster*, and two—*obliquus* and *latipes ?* in Western Australia. In addition I have seen unidentified females from Sydney and Woy Woy in New South Wales and from various places in Queensland. While some of the undetermined females may belong to described males, it is probable that the number of species found to occur in Australia will be greatly extended with more intensive collecting and study. It is to be expected that other Oriental and New Guinea species may make their appearance in N. Queensland.

The following table must of necessity be regarded as merely tentative; it is based largely on male characters, since the female sex of several is unknown.

Table of Species of Eumerus.

1. Antennae black; pale abdominal markings meeting in midline .... *E. obliquus* F.
   Antennae yellowish; lunules separate 2
2. Pubescence golden; posterior tarsi of ♂ dilatate, white, the posterior metatarsi not dilatate nor white .... *E. aurifrons* Wied.
   Pubescence of head never golden, posterior tarsi in ♂ not as above 3
3. Posterior metatarsi dilatate in ♂ 4
   Posterior metatarsi at most incrassate 5
4. The dilated posterior metatarsi clothed with brilliant silvery white pubescence .... *E. peltatus* de Meij.
   The dilated metatarsi brown .... *E. latipes* ? Macq.
5. Abdomen with long silvery pubescence on second and third segments in ♂ .... *E. argyrogaster*, n. sp.
   Abdomen not clothed as above 6
6. Posterior femora with small subapical flange on ventral surface .... *E. macquarti*, nom. nov.
   Posterior femora simple .... *E. simplex*, n. sp.

EUMERUS OBLIQUUS F.

Milesia obliquus Fabricius, 1805, p. 194.—*Eumerus ciliitarsis* Loew, 1848, p. 120. —For further references and synonymy see Kertesz, *Cat. Dipt.*, vol. v.

A robust thick-set species characterized by the abdominal lunules uniting across the median line.

♀. Eyes separated above by one-third of the distance from vertex to antennae and in front by approximately half that distance, clothed with short sparse whitish pubescence almost absent above; front widened anteriorly, vertex and ocellary region black with black erect hairs, a very narrow line of grey tomentum along the orbits, remainder of front densely clothed with greyish-white pubescence, punctate with black near ocelli, with long dense forwardly directed

greyish-white pubescence; face rather flat, somewhat retreating, clothed with dense pale tomentum and long pale pubescence similar to front, posterior orbits with white tomentum; antennae black, the third joint ovate, only slightly longer than deep.

Mesonotum black, rather dull, with moderately close and conspicuous punctures, anterior margins and humeral angles whitish tomentose, the median line white to suture, thence two admedian white lines are traceable to half-way between suture and scutellum, suture white tomentose, lateral margins with similar white clothing more conspicuous behind suture; pubescence mainly greyish but appearing dark from most directions; scutellum black, the extreme apex serrate and obscured by a narrow fringe of grey tomentum; surface punctate as on mesonotum, pubescence rather long and denser than on mesonotum, greyish-white; pleural segments punctate as on dorsum, with greyish-white pubescence on mesopleuron, sternopleuron and pteropleuron. Abdomen rather short and broad, apex widely rounded, black, rather closely punctate, 2nd, 3rd and 4th segments with oblique greyish-white tomentose bands extending from the posterolateral angle of each segment to the anterior margin in the midline; the bands on the second segment appear very narrowly separated at the inner end; those on the hind and fourth distinctly meet, on the second and third segments the bands occupying oblique impressions; on the second segment a narrow sublateral band of greyish-white tomentum is visible when viewed from behind; this joins the oblique band in front of the posterolateral angle; pubescence mainly short and dark on disc, except on bands, longer pale pubescence present along lateral borders and clothing most of fourth segment. Legs black, the knees and extreme apices of tibiae narrowly brownish-yellow, tarsi infuscated, the apical segments brownish-yellow; pubescence long, whitish, rather dense, especially on posterior legs; posterior femora strongly incrassate with a short subapical serrate flange on anteroventral margin, and a few short spines on posteroventral margin; posterior tibiae strongly incrassate in apical half; posterior metatarsi incrassate, but not dilatate, tarsi simple. Wings clear, venation as in genus. Halteres yellowish-brown.

♂. Differs from female in having the eyes meeting in front for a short distance, the anterior facets being slightly larger than the others, and in having the posterior tarsi and metatarsi laterally compressed with the exception of the apical joint, the upper margin fringed with black bristle-like hairs. Dimensions, 7 mm.

Hab.—New South Wales: Sydney (on window 7.1.24). Western Australia: Swan River, Merredin (Newman). (Introduced.)

The general appearance is quite unlike any other known Australian species; it is much broader proportional to the length and this, with the hairiness of the clothing, gives the species a decided bee-like appearance. The presence of oblique bands in place of the ordinary lunules is also distinctive; they appear as a series of inverted Vs. From the descriptions, the species would appear to approach most closely to *E. flavicinctus* de Meijere among the Oriental species, but there are too many differences for the species to be regarded as identical.

The above description was written under the impression that the species was an undescribed one native to Australia; it agrees, however, so well with Loew's description of *E. ciliitarsis*, a synonym of *E. obliquus*, that I have no doubt that the species has been introduced into Australia. The species appears to have a wide range in Africa and Southern Europe, but is not recorded by Brunetti from India.

EUMERUS AURIFRONS Wied.

Eumerus aurifrons Wiedemann, 1824, p. 32; de Meijere 1908, p. 218; Brunetti, 1923, p. 252, Pl. vi, fig. 2, 3.—*E. splendens* Wiedemann, 1830, p. 114; Brunetti, *op. cit.*, p. 218.

A widespread Oriental species whose range includes Queensland. The distinctive yellow clothing on the head, the separated eyes in the male and the structure of the hind tarsi in the same sex render it readily recognizable. The posterior metatarsi are normally incrassate, but not dilatate, dark with a narrow yellow apex; the remaining tarsal joints are flat, dilated and snow white in colour. Mr. J. Mann has bred this species from prickly pear (*Opuntia*).

Hab.—Queensland: Great Palm Island (Hardy, May, 1925), Brisbane (Mann), Townsville (Dodd, 26.6.02); extra-limital to India.

EUMERUS PELTATUS de Meijere.

Eumerus peltatus, de Meijere, 1908, p. 223.

Specimens of both sexes have been bred by Dr. T. L. Bancroft from a native fruit, and by Mr. J. Mann from rotting prickly pear (*Opuntia* sp.).

The species is easily distinguished in the male by the enormously dilated hind metatarsi. The whole of the hind tibiae and tarsi are clothed with long silvery white pubescence, but only the metatarsi are dilated, the tarsi being of normal size. The female is hardly to be distinguished from the females of other allied species; compared with the female of *E. simplex* it differs in the pubescent eyes and in the denser white pubescence of the anterior portion of the front and of the face; the posterior metatarsi are not dilated, but are brown, tipped with a little white pubescence; the other posterior tarsal joints are similarly though more sparsely tipped with white pubescence.

Hab.—*Queensland*: Eidsvold (Dr. T. L. Bancroft), Brisbane (J. Mann); extra-limital, New Guinea (de Meijere).

EUMERUS LATIPES Macq.

Eumerus latipes Macquart, 1846, p. 133.

"Ater. Abdominie lunulis albis. Pedibus nigris, tibiis meta-tarsisque posticis dilatatis.

"Long 3½l. ♂. Face et front dénudés. Antennes brunâtres. Yeux nus. Thorax à reflets verts et violets. Abdomen allongé, d'un noir bleuâtre. Ailes grisâtres; première cellule postérieure anguleuse, à deux appendices.

"De la Nouvelle-Hollande, Collection de M. Bigot".

The above description is so short as to be almost worthless, except for the reference to the posterior tibiae and metatarsi. If Macquart is correct in describing the tibiae as dilatate I have not seen the species. I believe, however, that the name should apply to a species in which the posterior metatarsi are widely dilatate, but the posterior tibiae at the most only incrassate. The eyes also are pubescent, not bare as described by Macquart, who, however, was apparently dealing with a denuded specimen, while the legs, though black, have the knees yellow.

A female in Mr. Hardy's collection from Hobart (Jan., 1924) and one in the National Museum from the same locality (C. E. Cole 13.1.18) appear to belong to this species. They are hardly to be separated from the species herein described as *E. simplex*, except by the pubescent eyes.

Specimens of this species are in Mr. Hardy's collection from Sydney (11.9.1920) and Dunalley, Tasmania (24.12.1917); in the South Australian Museum from Georgetown, Tasmania (March, 1913) and in the National Museum, Melbourne, from Hobart (C. E. Cole, 21.4.17 and 10.11.17). I have recently taken specimens at Geraldton, W.A. (5.9.26).

EUMERUS ARGYROGASTER, n. sp.

♂. A bronzy-black species with brilliant silvery abdominal pubescence. Head black; eyes contiguous for a considerable distance, densely brown pubescent, the upper facets somewhat, but not greatly, larger than the lower; ocellary triangle elongate, black, shining with dark erect hairs; frontal triangle small, with dark hairs; face retreating towards oral margin, rather flat, black with faint greenish iridescence, pubescence dark; cheeks with lower posterior angle of orbits with some white pubescence; posterior orbits mostly dark, but with some white tomentum below and a small spot of similar colour opposite humeral callosity; antennae yellowish-brown, the third joint infuscated along the anterior upper margin, rather elongate, distinctly longer than deep. Mesonotum bronzy-black with purple reflections in places, some whitish tomentum on extreme anterior margin and on humeral angles, pubescence erect, mainly dark, but with some whitish prescutellar hairs; scutellum similar to dorsum, with a distinct serrated apical flange of about twelve dentations, pubescence dark, both mesonotum and scutellum shining; finely and not closely punctate; pleural segments similar, pubescence sparse, whitish on sternopleuron, pteropleuron and posterior edge of mesopleuron, dark elsewhere. Abdomen elongate, black; seen from behind the usual three pairs of lunules are present on the second, third and fourth segments, that on the second being abbreviated to a small spot on each side of middle line; seen from in front the lunules on the second and third segments are completely concealed by long decumbent brilliant silver pubescence which clothes the abdomen from the basal third of second segment to the apex of third; venter dark with some fine whitish pubescence on sternites. Legs bronzy-black, the extreme apex of femora and the base of apex of tibiae brownish-yellow; anterior tarsi yellowish-brown, the metatarsi somewhat infuscated; intermediate legs wanting; posterior femora not greatly thickened, simple, with a few small spines on ventral surface; posterior tibiae noticeably, but not greatly, incrassate in apical half; posterior metatarsi strongly incrassate, but not dilatate, black, the extreme apex yellowish, other tarsal joints small, narrow, brownish; pubescence on hind legs rather sparse, mainly whitish on coxae and femora, at extreme base and on dorsal apical third of tibiae and on apex of metatarsi; golden pubescence present on under surface of apex of tibiae and of metatarsi and tarsi. Wings hyaline; venation as in genus; halteres brown.

Length, 7 mm.

Hab.—Queensland: Eidsvold (28.4.24, Bancroft).

Described from a single male given me by Dr. I. M. Mackerras. The species is unique, at any rate among known Australian forms, in the presence of the long silvery abdominal pubescence; this is practically invisible from behind, but presents a most brilliant appearance when the insect is viewed from in front. This clothing is probably sexual, but no female has been found which could be regarded as conspecific. Two males have recently been sent me, taken by Mr. F. A. Perkins on Palm Island, N. Queensland. They differ somewhat in the extent of the white pubescence on the abdomen but are probably both somewhat abraded.

*EUMERUS MACQUARTI, nom. nov.

Eumerus fulvicornis Macquart, 1850, p. 146 (nec *E. fulvicornis* Macquart, 1834, p. 528).

I identify as this species several specimens from Tasmania and New South Wales which agree closely with Macquart's description. In both sexes there is a slight flange-like projection from the posteroventral edge of the hind femora which bears one or two small spines. This projection is not mentioned by Macquart and his name would apply almost equally well to another species with simple femora; in the latter species, however, the wings are absolutely clear, whereas in the present specimens the wings are slightly shaded with brown, corresponding with Macquart's description, "Ailes claires; nervures un peu bordées de brunâtre".

Hab.—New South Wales: Sydney (24.9.22). Tasmania: Mt. Wellington (G. H. Hardy, 4.3.17, Jan., 1924), Hobart (G. H. Hardy, 3.10.15, Jan., 1924).

EUMERUS SIMPLEX, n. sp.

Closely allied to *E. macquarti*, but with simple femora and clear wings.

♂. Head black; eyes bare, contiguous for a short distance anteriorly; finely faceted, the anterior facets only slightly larger; vertex and ocellary triangle black, set with black hairs, the apical portion of ocellary triangle grey tomentose with grey pubescence; frontal triangle with ochraceous tomentum and dark pubescence; face rather flat, somewhat retreating, black, slightly bluish, sparsely grey tomentose with dark pubescence; posterior orbits white tomentose except above, with some sparse white pubescence at inferior angle. Antennae brownish-yellow, the third joint somewhat darkened along upper margin; slightly longer than deep. Mesonotum black, rather feebly metallic iridescent, somewhat bronzed in centre, moderately finely punctate, a pair of white tomentose admedian lines present from outer margin to beyond suture, only visible when viewed from behind; pubescence rather short and fine, mainly pale. Scutellum bronzy-black, shining, punctate as on mesonotum, with well marked apical flange, bearing about fourteen dentations, pubescence as on dorsum. Pleurae black, slightly brassy, with rather sparse pale pubescence. Abdomen elongate, black, finely punctate, somewhat brassy at sides of segments, with three pairs of curved transverse white tomentose lunules on second, third and fourth segments, situated near or slightly beyond middle of segment anteroposteriorly, and not meeting across midline, those on second segment shortest; pubescence short, appressed, mainly dark, some scanty whitish pubescence at sides of segments, longer at basal angles of second. Legs mainly black with metallic reflections, the extreme base of femora, knees and apex of tibiae yellowish, tarsi infuscated above, with dense golden yellow clothing beneath; posterior femora simple, not incrassate and without flange, a row of short spines on each side of ventral surface before apex; posterior tibiae slightly thickened in apical half, but not greatly incrassate; posterior metatarsi longer and thicker than other tarsal segments, but not greatly incrassate or dilatate; pubescence rather scanty, mainly pale, a moderately conspicuous patch at apex of hind tibiae. Wings clear; venation normal; calypters brownish-yellow.

♀ resembles ♂; eyes separate, bare; front rather narrow, width about half that of one eye, black, shining, moderately closely set with small punctures, with black hairs; orbits narrowly grey tomentose in anterior portion; otherwise as in ♂.

Dimensions, 6 mm.

* A change of name is necessary since *Eumerus fulvicornis* was previously used by Macquart for another species.

Hab.—Victoria and New South Wales. Holotype, Cheltenham (17.11.1$\female$, C. E. Cole); allotype, Eltham (22.2.19, C. E. Cole); paratype $\male$ Sydney (24.9.22).

The paratype is slightly smaller (5 mm.) and the metallic reflections differ slightly in different parts; these reflections do not, however, appear to be constant. The species may be recognized by the simple posterior legs in the male and by the bare eyes. Under high powers of magnification a few separate fine hairs may be detected, but with an ordinary hand lens the eyes appear quite bare, not densely pubescent as in *E. macquarti* and other species.

Subfamily Volucellinae.

"Antennae moderately long, and even if elongate, mainly pendent; arista normally plumose; face very considerably produced into a blunt or more conical snout, sometimes of considerable length. Body usually robust, not linear or attenuated. Legs simple. Wings with marginal cell closed or open; third vein not looped downward into first posterior cell; fourth vein distinctly recurrent at tip, ending some distance from wing-border; anterior cross-vein before middle of discal cell" (Brunetti, 1923, p. 134).

The above description is copied directly from Brunetti. The characters cited are not very satisfactory, though Brunetti regards the subfamily as a natural one. The only genus occurring in Australia is *Graptomyza*, which affords exceptions to at least two of the main characters of *Volucella*. Thus cell R_1 is widely open, not closed as in *Volucella*, and the arista, though normally plumose, may be bare or practically so. These are two of the three characters given by Brunetti in his key to the subfamilies of the Syrphidae, the third character, the fourth vein (M_{1+2}) recurrent at tip, occurs also in several genera of Syrphinae.

There seems little indeed to exclude the genus *Graptomyza* from the Syrphinae, except the occurrence in probably the majority of the species of a plumose arista. Brunetti states that a plumose arista is entirely foreign to the Syrphinae (*op. cit.*, p. 153).

While endemic species of *Volucella* are unknown from Australia, several species of American Syrphidae, including at least two species of *Volucella*, have been brought over by the Prickly Pear Experiment Committee for experiments in the control of prickly pear (*Opuntia sp.*). There is no evidence, however, that these have succeeded in establishing themselves outside the laboratory cages.

Graptomyza Wied.

Graptomyza Wiedemann, 1830, p. 206; Brunetti, 1903, p. 135.

Head as broad as or broader than thorax, transverse; epistome produced as a conspicuous snout, projecting diagonally downwards, varying in length in different species; proboscis elongate, then bifid at tip. Eyes widely separated in both sexes (at least in Australian species). Antennae with first and second joints small, third very elongate, three or four times longer than deep, porrect or somewhat drooping, compressed, arista bare or conspicuously plumose. Thorax short, subquadrate with rounded corners; humeri with projecting calli generally very distinct, softly pubescent, but with a distinct chaetotaxy; scutellum with distinct deep transverse depression on disc (at least in Australian species). Abdomen shortly oval, or a little narrowed at tip, arched, thick, softly pubescent. Legs comparatively short and weak. Wings of normal size, *vena spuria* absent; M_{1+2} and M_{3+4} bent sharply up in apical portion generally at a right or acute angle, the section nearly or quite straight, anal angle of wing and alulae well developed; squames of normal size, with fringes.

The above description is taken, somewhat modified, from Brunetti. The latter author makes no mention of the eyes in the male, possibly because all the species he records are represented by female specimens. De Meijere (1908), in dealing with the Oriental and Papuan species, mentions the sex of his specimens in only two instances; in three of the species described as new by that author the sex of his specimens, unique in each instance, is not given. In the Australian specimens before me, where both sexes are represented, the eyes are widely separated in both and indeed there is little to distinguish the sex except the genitalia.

The possession of a definite chaetotaxy is rare in the Syrphidae; Brunetti says that it generally consists of "one or two presutural bristles, three supra-alar or post-alar, two or three on posterior calli, two notopleural and a row on hind margin of dorsum; also scutellum bearing strong bristles, or with a general row of numerous bristles on hind margin, this system apparently slightly varying with the species". I find in the Australian species that the chaetotaxy varies widely with the species, though apparently constant within each.

Graptomyza has hitherto been represented in Australian faunal lists by but one species, *Graptomyza maculipennis* de Meijere, described from Sydney. This still remains the only southern representative of the genus, but I have recently received from Mr. F. P. Dodd, of Kuranda, specimens of three distinct species, allied to New Guinea forms, but all apparently distinct from any described by de Meijere.

Table of Species of Graptomyza.

1. Wings pictured .... *G. maculipennis* de Meij.
   Wings clear 2
2. Mesonotum black with yellow shoulders; abdomen banded ...... *G. flavicollis*, n. sp.
   Mesonotum mainly pale, with darker broad median area; abdomen spotted or striped 3
3. Abdominal markings confined to a spot near posterolateral angles of second and third segments; ♂ with intermediate legs simple .... *G. doddi*, n. sp.
   Abdomen with interrupted median vitta and narrow oblique dark markings at postero-lateral angles of second and third segments; ♂ with intermediate legs plumed .... *G. plumifer*, n. sp.

GRAPTOMYZA MACULIPENNIS de Meij.

Graptomyza maculipennis de Meijere, 1908, p. 279, Pl. 8, fig. 28, 29.

A well marked species readily distinguished from other known Australian forms by the pictured wings.

The mesonotum is dark and the abdomen reddish-brown with the somewhat obscure markings described by de Meijere; the chaetotaxy appears to be as follows: 2 notopleural, 2 mesopleural, 3 supra-alar, 3 post-alar, a row along posterior border of which the outer bristles are the longest, and two apical scutellar bristles; the bristles are somewhat obscured by the pubescence.

Hab.—New South Wales: Sydney, Botany Bay (Biro, 1900), Roseville (6.10.14 and 8.1.23).

GRAPTOMYZA FLAVICOLLIS, n. sp.

♀. A species with black thorax with yellow shoulders, and yellowish abdomen with black transverse markings.

Front broad, posterior half black, anterior yellow, a narrow band in front of black and a broad longitudinal band, including lunule, tawny yellow, with distinct discrete round punctures, more obvious on the black and absent from

the clear yellow areas at the sides of lunule; face clear yellow, a darker, rather obscure brownish median vitta present and a similar band from lower border of eye to oral margin, outline of face concave below antennae, thence produced to oral margin, the facial knob moderately distinct, epistome produced downwards and forwards, less prominent than in *G. doddi*; pubescence on head very short and scanty, practically restricted to vertex and dark portion of front, some yellowish hairs on genal angles; eyes practically bare, a few microscopic hairs visible with high magnification. Antennae tawny-yellow, third joint elongate, about twice as long as wide, arista with short, rather sparse hairs on dorsal border. Mesonotum shining black with slight purple reflections, humeral callus and a square patch immediately behind callus clear yellow, pubescence fine, appressed, brownish; scutellum clear yellow, with deep depression shaped as in *G. doddi* overhung by some recurved fine yellow hairs, without obvious tomentum in depth; pleurae black, a large yellow patch present on mesopleuron; chaetotaxy reduced; two short, rather stout, black supra-alar bristles with some short, black hairs above wing roots; three black post-alar bristles, one long yellow mesopleural bristle and a pair of short, yellow bristles on apical margin of scutellum widely separated and arising each from a small granule; bristles on posterior margin of mesonotum represented by a row of fine, yellow hairs. Abdomen brownish-yellow with black, transverse markings; first segment entirely yellow, second segment with a broad, transverse band, obliquely narrowed at sides where it reaches posterior border, the upper margin of band shallowly indented in midline; third segment with a similar, but rather narrower band produced forwards in midline almost to anterior margin, the extreme sides also blackish; fourth segment with a longitudinal black median vitta narrowed posteriorly and a black oblique mark along each side from basal third to apex, the extreme basolateral angle also blackish; pubescence short, appressed, brownish. Venter brownish-yellow. Legs brownish-yellow, the tarsi lighter, the posterior femora rather thicker than normal with a row of short spines on each edge of ventral surface before apex. Wings clear, venation normal. Calypters and halteres yellowish.

Length, 4 mm.

Hab.—N. Queensland: Cairns District (F. P. Dodd).

Described from a single female sent to me by Mr. Dodd of Kuranda. The species is quite distinct from any known Australian species and does not agree with the description of any Oriental or New Guinea form. The spines on the under surface of the posterior femora appear to be most unusual in the genus, since in his generic diagnosis one of the characters cited by Brunetti is, "Legs . . . . . never incrassated, nor in any way armed".

GRAPTOMYZA DODDI, n. sp.

A yellowish-brown species with lateral dark spots on abdomen.

♂. Head yellow, the upper portion of occipital region and the spot on which the ocelli are situated black; front broad, wider than the width of an eye, subquadrate, parallel-sided; face strongly produced anteriorly to facial knob, thence falling almost perpendicularly to oral margin, pubescence fine, rather sparse, yellow; eyes evenly faceted, bare; antennae darker yellow, almost golden, the third joint long, oblongate, arista rather sparsely plumose on upper surface. Mesonotum yellow with a broad somewhat darker yellowish-brown central area, narrowed in front and bearing a dark, blackish W-shaped mark posteriorly, the triangle between the central limbs bright yellow; scutellum yellow; depression

transversely oval, the basal side slightly flattened, filled with fine yellow tomentum; pleurae yellow; pubescence soft, yellow, moderately dense on dorsum; chaetotaxy: 2 notopleural, 1 supra-alar, 3 post-alar (one of which is at extreme inner end of posterior callus) and one prescutellar bristle on each side of dorsum, the prescutellar and inner post-alar bristles are dark, the others yellow; mesopleuron with a single yellow bristle; scutellum with an apical pair of dark bristles. Abdomen yellow-brown, becoming darker posteriorly, second and third segments each with a small dark mark on posterior border on each side near, but not at, the posterolateral angle; pubescence fine, apparently dark with some brighter yellow pubescence on base of second, and at basolateral angles of third and fourth segments. Venter yellowish-brown, pubescence yellow. Legs yellow, the apices of posterior femora and tibiae and the posterior tarsi infuscated; the posterior tibiae are slightly darker than the other legs and bear some short black bristle-like hairs on anteroventral surface in outer half; pubescence otherwise mainly yellow. Wings clear, venation normal. Calypters and halteres yellow.

♀. Resembles male, but rather larger and more robust, forehead with black of occiput extending approximately half-way down front; chaetotaxy all black, in others the three posterior bristles black only, mesopleural bristle always yellow.

Dimensions, ♂, 4 mm.; ♀, 5 mm.

Hab.—North Queensland: Cairns District (F. P. Dodd, 3 ♂, 5 ♀—no other data).

This species appears related to *G. punctata* de Meijere from New Guinea, but differs in the thoracic and abdominal markings.

In the females there is frequently a median dark vitta on the fourth abdominal segment and an ill-defined mark at posterior margin of second segment in the middle line; the yellow pubescence on the thorax is concentrated along two admedian lines, not evenly diffused as in the male.

GRAPTOMYZA PLUMIFER, n. sp.

♂. A golden-yellowish species with three dark marks on the abdominal segments and plumed intermediate legs.

Head yellow, somewhat tawny, the vertex dark brown; front over three-fourths the eye width at vertex, gradually widened anteriorly, yellow except for narrow brown band at vertex, surface nitid with scattered discrete small punctures, not tomentose, but with some rather scanty, short, pale pubescence, dark on vertex; face similarly coloured, deeply concave below antennae, thence produced to oral margin, the central knob moderately distinct, epistome well produced, but rather less than in *G. doddi*; eyes bare, evenly faceted. Antennae yellow, the third joint large oblongate, the depth approximately three-fifths the length, arista dorsal, with some short sparse hairs on upper side. Mesonotum yellow, with a broad central darker brown area extending the length of mesonotum, the lateral margins similarly stained, pubescence short, decumbent, yellow; scutellum yellow, with deep transverse depression as in *G. doddi*, but deeper and apparently containing but scanty tomentum in depth; pleural segments yellow, laevigate, with some scanty yellow pubescence; chaetotaxy: 1 supra-alar, 3 post-alar, a row along posterior margin, 1 mesopleural and 2 scutellar bristles, the latter short, widely separated and each arising from a small granule, all bristles yellow and shorter than in *G. doddi*. Abdomen yellow, the second, third and fourth segments with a median, longitudinal black mark, the whole forming an interrupted vitta, widest on second segment; the second and third segments also with a narrow oblique mark near

latero-posterior angle on each side; pubescence short, appressed, of same colour as the derm, some longer pubescence on first segment. Venter yellow. Legs yellow, the intermediate tibiae, metatarsi and tarsi fringed along each side with long, closely set bristles, longest on metatarsi and gradually failing on terminal tarsal joints, the whole bearing an extraordinary resemblance to a small feather; anterior metatarsi and tarsi flattened and fringed with yellow bristles. Wings clear, venation as in genus; calypters and halteres yellow.

Length, 4 mm.

Hab.—North Queensland: Cairns District (F. P. Dodd).

Described from a single male sent by Mr. Dodd in company with *G. doddi*. The plumed appearance of the intermediate legs is most striking; it may, however, be sexual; in this case the female should be readily recognized by the abdominal markings.

NOTES ON AUSTRALIAN DIPTERA. No. ix.

By J. R. MALLOCH.
(Communicated by Dr. E. W. Ferguson.)

(Six Text-figures.)

[Read 27th October, 1926.]

I present in this paper descriptions of some new, and some previously described, genera and species of Australian flies. There is not sufficient material available yet to permit publication of revisions of the families Ephydridae and Chloropidae, and there is a paucity of material in Helomyzidae and Neottiophilidae. In the Helomyzidae I expect there are many more genera and species yet to be discovered, but possibly the genus *Tapeigaster* may be the only representative of the small family to which it belongs, and the status of which has created some difference of opinion amongst specialists. I have briefly discussed the relationships of this genus in the present paper.

I have delayed presenting a generic synopsis of the family Sapromyzidae pending the receipt of some additional material from Dr. E. W. Ferguson, and I am inclined to believe that there must be still a large number of species of this family unknown to me, as new forms are constantly occurring in any moderate sized accession of material reaching me.

Unfortunately several of the species described in this paper are represented by specimens from the British Museum and the United States National Museum, so that the actual type specimens will thus not be available in Australia to students of the order. It is hoped, however, that, later, specimens of those species will become available for deposition in some Australian museum. I have made the descriptions as comprehensive as possible so that it will undoubtedly be possible to identify the species referred to without an examination of the type specimens, unless some very closely related species yet unknown to me should occur in Australia. When the wing markings are intricate and a word description might possibly be difficult to understand I have figured the wing, but one must understand that there is a certain amount of variation always present in the markings of such forms, more especially in those that have the wings most intricately marked, and allowance must be made for this in identifications.

Family Ephydridae.

Genus PARALIMNA Loew.

I presented a key to the three Australian species of this genus known to me in Part vii of this series of papers, and now describe a fourth Australian species.

PARALIMNA STIRLINGI, n. sp.

Male.—Black, opaque, densely white dusted. Frons almost completely whitish-grey dusted, only a faint brownish mark in front of ocelli; palpi grey dusted. Thorax with indications of dark dots at bases of setulae quite evident, and larger

dots at bases of the bristles; no dark dots on pleura. Abdomen marked as in *millepuncta*, but the brown markings narrower. Legs black, grey dusted, extreme bases of all tibiae, and basal segment of all tarsi, yellow. Wings clear. Calyptrae and halteres whitish.

Frons bristled as in *millepuncta*, the two setulae between orbital bristle and eye present; genal bristle weak; lower bristle of facial pair short. Each humerus with one long bristle and a few short setulae; scutellum flattened, the four long bristles subequal. Fore femur with a rather wide break at middle of the postero-ventral series of bristles; legs otherwise as in *millepuncta*.

Length, 4 mm.

Type, and 3 male paratypes, Alexandria, N. Australia, 13-20.3.1906 (W. Stalker).

Type in British Museum.

This species is named in honour of my uncle Joseph Stirling, of Childers, N. Queensland, who has taken an active interest in the agriculture of the colony for the past 60 years.

The species will run to *millepuncta* in my key, but there is no very pronounced break in the posteroventral series of bristles on the fore femur in that species, and the frons and dorsum of head are conspicuously spotted with dark brown, as is also the upper part of mesopleura, which is not the case in *stirlingi*.

Family Chloropidae.
Subfamily BOTANOBIINAE.
Genus THYRIDULA Becker.

I have already described two species of this genus from Australia. Both of these have the scutellum conspicuously narrowed at apex, the general shape being isosceles triangular, but in the present species the scutellum is broadly rounded at apex (Text-fig. 1). Another distinction between the new species and the two above referred to lies in the rugose pleura of the former, the others having the pleura smooth.

THYRIDULA RUGOSA, n. sp. Text-fig. 1.

Female.—Testaceous yellow, dorsum of thorax more brownish, the mesonotum with traces of four or six greyish vittae; apex of scutellum yellowish. Legs reddish testaceous, tibiae with a dark central annulus, faint on fore pair; tarsi yellowish. Wings clear, veins pale, dark at junction of second and third.

Frons quite densely hairy; face without a central carina; proboscis geniculated; arista pubescent. Thorax with many piliferous punctures on dorsum; disc of scutellum rugose, the outline and marginal armature as in Text-figure 1; mesopleura and sternopleura distinctly rugose. Abdomen short, but little longer than the scutellum. Legs stout, hind pair notably so. Outer cross-vein oblique.

Length, 3 mm.

Type, Cairns, N. Queensland (J. F. Illingworth).

Type in U. S. National Museum.

Family Agromyzidae.
Subfamily MILICHIINAE.
Genus MILICHIA Meigen.

In a previous paper of this series I presented a synopsis of the characters for the separation of the three genera then known to me as occurring in Australia.

The genera *Stomosis* Melander and *Milichia* have been received since. It might be premature to present at this time an enlarged generic synopsis, so I defer doing so until later, merely listing at this time the salient characters of the genus *Milichia*.

Closely related to *Milichiella*, having the same shape of wing, wide at base and narrowed at apex, with the same deep oblique costal incision before apex of first vein. It has also on each orbit two strong bristles on upper half, the anterior one directed straight forward, and the posterior one curved backward. In *Desmometopa*, *Hypaspistomyia*, and *Stomosis* these bristles (2 or 3) are directed obliquely outward over the eye. From *Milichiella* the present genus is distinguished by the lack of an angular incision in the hind margin of eye near middle.

MILICHIA PISCIVORA, n. sp.

Male and female.—Black, subopaque, the thorax and abdomen densely dark grey dusted, the frons and face in male rather densely white dusted; abdomen in male with a large rather faint brownish mark on each side of each tergite except fourth. Wings hyaline. Halteres fuscous.

Frons of male about one-fourth of the head width at vertex, much narrowed anteriorly; of female, one-third of the head width at vertex and but little narrowed anteriorly, each orbit with but two strong bristles, one anteriorly directed above middle and the other backwardly directed between it and vertex; postverticals convergent; ocellars long; interfrontalia with the usual two series of bristles, the anterior one on each side strong, the orbits with short setulae anteriorly; antennae short, third segment rounded; arista subnude; cheek linear, marginal bristles long, increasing in strength to vibrissae; proboscis stout; palpi broad. Thorax with one strong and one weak pair of dorsocentrals and one strong pair of acrostichals in front of scutellum; mesopleura bare; sternopleura with three bristles. First and fourth visible tergites elongated, the former in male with short but distinct erect fine curled hairs on sides, fourth with a few short apical bristles. Legs normal. First posterior cell of wing narrowed at apex.

Length, 3-3·5 mm.

Type, male, and four male paratypes, Townsville, Queensland, 24.2.13, "breeding in decaying fish". Allotype, Townsville, Queensland (F. H. Taylor). Paratypes, two females, Sydney, N.S.W., 11.2.24.

Family Ortalidae.

It is not my intention to deal *in extenso* with the members of this family, as I understand this has been undertaken by Professor Bezzi. I have before me, however, a very exceptional species which, in habitus and coloration, so closely resembles some species in the family Clusioididae that I feel it is incumbent upon me to deal with it at this time. I cannot find any description that appears to fit the species so describe it as new.

Genus CLUSIOSOMA, nov.

Generic characters.—Postverticals much longer than the small ocellars, convergent; four strong verticals; frons not more than one-fifth of the head width, each orbit with four bristles, the upper two backwardly curved, the lower two incurved, uppermost one short and weak, about in line with anterior ocellus, the second strongest of all; third antennal segment about twice as long as its greatest width, tapered apically; arista loosely plumose; face subvertical, slightly concave;

vibrissae absent. Thorax with a strong humeral, one pair of dorsocentrals, a pair of prescutellar acrostichals, two mesopleurals, one sternopleural, no propleural, and the centre of propleura fine haired; scutellum subtriangular, slightly flattened above, with six marginal bristles, the median pair very short. Hypopygium of male small, with the usual coiled process; female ovipositor tapered to a tube-like apex. First, third, and fifth veins setulose above, third and fourth setulose below; anal cell produced in the form of a slender point at apex behind. Fore femur setulose below in both sexes; preapical tibial bristle lacking.

Genotype, the following species.

CLUSIOSOMA SEMIFUSCA, n. sp.

Male and female.—Head clay-yellow, second antennal segment and ocellar spot black, a dark streak on centre of male frons on upper half, face and cheeks whitish tomentose. Thoracic dorsum reddish testaceous, humeri whitish, a dark vitta along mesial or inner margin of each humerus which extends to base of wing, and four narrow dark discal partial vittae behind suture; pleura yellowish-clay coloured, with a dark vitta along middle; scutellum dark on disc; postnotum brown. Abdomen brownish above, paler below. Legs yellowish testaceous. Wings greyish at bases, brown or fuscous from apex of auxiliary vein to tip, paler posteriorly. Halteres testaceous yellow.

Postocular setulae black on upper half; lower occiput with one bristle. Thoracic dorsum with decumbent dark setulae. Fore femur in male much thicker than the other pairs, with black ventral bristles which are short on anteroventral surface and become long and strong apically on posteroventral surface; female with a few posteroventral bristles on fore femur; fore tibia in male dilated and downy at apex, the production on ventral side; hind femur with a few short weak preapical anteroventral setulae; mid tibia with one or two short weak preapical anteroventral setulae; hind tibia with one or two anterodorsal and anteroventral setulae. Inner cross-vein of wing a little beyond middle of discal cell; first posterior cell not narrowed apically.

Length, 4·5-5·5 mm.

Type, male, allotype, and one male paratype, Cairns, N. Queensland (Illingworth).

Type in United States National Museum.

This genus would appear to find its best affinities in the Cephalinae, but it agrees with no genus known to me.

Family Sapromyzidae.

I present in this paper the descriptions of some genera and species which were lent to me for description by Dr. Aldrich of the United States National Museum. The types are in that institution.

STEGANOPSIS ANNULIPES, n. sp. Text-fig. 2.

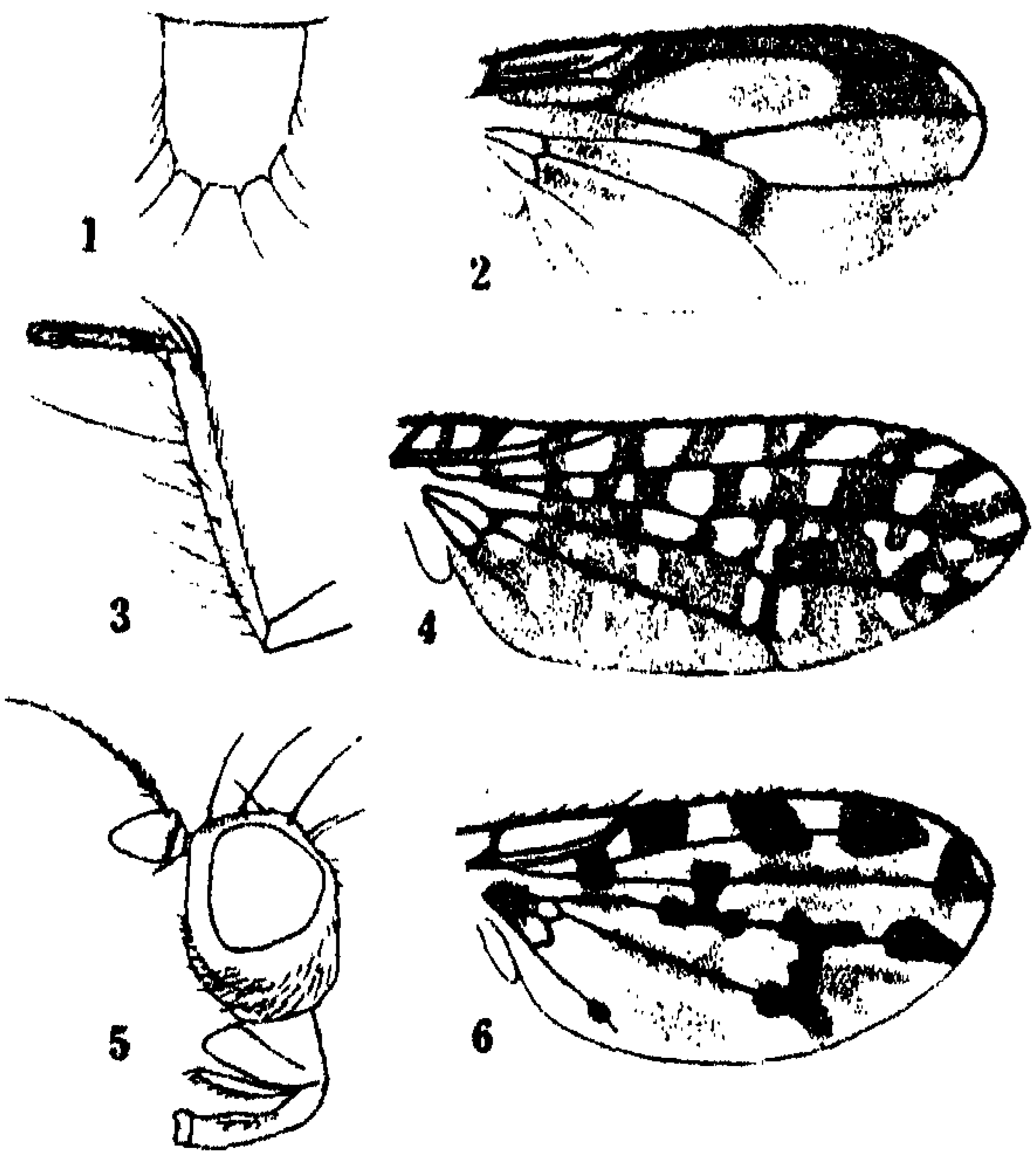
Female.—Black, shining, the entire body in type specimen greasy, so that it is not possible to say if there are markings present, though the tip of the scutellum and parts of the pleura are yellowish, and the latter bear evidences of having dark dots. Antennae yellowish, third segment largely fuscous. Legs black, fore femora with a broad testaceous median band; fore tibia with a narrow subbasal band and a broader one beyond middle, basal segment of fore tarsus, and all of mid and hind pairs, pale yellowish testaceous. Wings fuscous, paler behind, marked as in Text-figure 2. Halteres fuscous.

Postverticals rather large, ocellars very small, anterior incurved orbitals as large as upper pair; arista plumose, hairs longest on upper side; antennae normal. Thorax with two pairs of prescutellar dorsocentrals. Fore tarsus rather thick, but not conspicuously dilated.

Length, 3·5 mm.

Type, Gordonvale, N. Queensland (Edmund Jarvis).

This species differs from any other in the genus known to me, by the annulate legs, the wing markings, and, if the thorax is unmarked on dorsum, it may be readily distinguished from the other described Australian species by that character also.



Text-fig. 1. *Thyridula rugosa*, scutellum.
Text-fig. 2. *Steganopsis annulipes*, wing.
Text-fig. 3. *Amphicyphus reticulatus*, hind tibia of male.
Text-fig. 4. *Amphicyphus reticulatus*, wing.
Text-fig. 5. *Trigonometopus fuscifrons*, head.
Text-fig. 6. *Huttonomyia maculipennis*, wing.

Genus AMPHICYPHUS de Meijere.

Generic characters.—Anterior pair of fronto-orbitals directed inward; basal antennal segment short, bare below, third tapered apically, less than three times as long as its basal width; arista short-haired; parafacial with some fine erect hairs at middle, lower part of inner margin of parafacial with some long bristly hairs; clypeus prominent and well developed; face slightly convex; palpi slender. Thorax with one pair of strong presutural dorsocentrals, the specimen so much damaged that it is impossible to decide if there are three or four pairs behind the suture; mesopleura with long hairs, amongst which one bristle is evident; sternopleura similarly haired, the two bristles weak; scutellum thick, slightly impressed on each side near apex, and at tip between the bristles, so that the apical pair

appear to be situated on two slight callosities. Preapical dorsal bristle on fore and hind tibiae slender, longer than metatarsus, and situated about one-third from the apices, mid tibia with a shorter, stouter bristle, hind tibia with two stout curved apical ventral bristles, the upper one shorter than the lower (Text-fig. 3). Wing venation as in *Sapromyza*.

AMPHICYPHUS RETICULATUS (Dol.). Text-figs. 3, 4.

Male.—Yellowish testaceous, slightly shining, with greyish dusting, especially on dorsum of thorax. Frontal orbits with brown spots at bases of the bristles; ocellar spot brown; a brown spot at middle of each parafacial, and another at lower angle of eye; face with six similar spots, three above middle, and three on lower margin; arista dark-haired. Thorax and scutellum brownish, irregularly spotted. Abdomen with a dark dorsocentral stripe basally, which is slightly divided centrally, and a dark dot at base of each of the stronger hairs. Femora with a brownish band beyond middle; tibiae each with a brown spot or band near base, and a band beyond middle. Wing brown, with many hyaline spots (Text-fig. 4).

Frons about 1·5 as wide as long, the orbits not differentiated, ocellar triangle and bases of the orbital and vertical bristles slightly raised; postverticals convergent; three verticals on each side; some long hairs on orbits laterad of the anterior incurved bristles; proboscis stout apically. Thoracic hairs long and erect. Abdomen ovate; hypopygium small. Fore femur without an anteroventral comb, the posteroventral bristles long and fine; mid femur with fine hair-like anteroventral and posteroventral bristles; hind femur with similar anteroventral bristles; dorsal hairs on fore and hind tibiae long and setulose.

Length, 3·25 mm.

Cairns, N. Queensland (Illingworth).

This genus is readily distinguished from any other known to me by the very peculiar apical pair of curved ventral bristles on the hind tibia. This may be a male character, but there are other characters which distinguish the genus from any other having the anterior fronto-orbital bristles incurved that must be found in the female, even if that sex lacks the bristles above referred to.

It is unfortunate that several of the new genera and species collected by Dr. Illingworth are represented by single specimens only and that the species must therefore be represented by the types in an American Museum rather than in one in Australia.

Genus TRIGONOMETOPUS Macquart.

This genus is distinguished from its allies by the absence of the presutural intra-alar bristle. Although the head in typical species of the genus is subtriangular in profile, the frons produced in front and the face receding below, in the species before me, and in some Oriental species, the head is not so formed, the face being but little or not at all receding below. In some other respects the species now described differs from typical species of the genus, e.g., in the scarcity of hairs between bases of antennae and eyes, in the situation of the postverticals, which are placed much below the margin of vertex, in the longer ocellar bristles, and the presence of a pair of presutural dorsocentrals and but two pairs of the latter behind suture.

TRIGONOMETOPUS FUSCIFRONS, n. sp. Text-fig. 5.

Male.—Head whitish-yellow, frons and a large mark on each side of occiput greyish fuscous. Thorax fuscous, with greyish dusting, humeri, sutures of pleura,

and a broad margin of scutellum, whitish-yellow. Abdomen yellowish testaceous. Legs testaceous. Wings yellowish hyaline, bases white. Halteres yellow.

Head as in Text-figure 5; arista very short haired. Thorax in type damaged by pin, but with very few dorsal hairs and evidently 1 + 2 dorsocentrals and one pair of prescutellar acrostichals; scutellum flat above, with four equal bristles; mesopleura and sternopleura each with one bristle. Abdomen elongate-ovate. Legs normal, no fore femoral comb. Inner cross-vein close to middle of discal cell; apical section of fourth vein but little longer than preceding section.

Length, 4 mm.

Type, Cairns, N. Queensland (J. F. Illingworth).

Type in U. S. National Museum.

The only species known to me with this coloration of head and scutellum.

HOMONEURA INDECISA, n. sp.

Male.—Tawny yellow, frons except orbits opaque, face a little shining, thorax and abdomen distinctly shining, fourth visible tergite of latter with a rather large black spot on each side, fifth with a much smaller spot. Antennae and palpi yellow. Wings without clouds on any of the veins.

Ocellar bristles shorter than the postverticals; all orbitals long and strong; antennae short, third segment rounded at apex, about 1·5 times as long as wide; arista plumose. Thorax with three pairs of long strong postsutural dorsocentrals, and eight to ten series of short intradorsocentral hairs. Fore femur with an apical comb of short black setulae on anteroventral surface, and four or five long posteroventral bristles; hind femur with one or two preapical anteroventral bristles; all tibiae with distinct preapical dorsal bristle. Inner cross-vein a little before middle of discal cell. Hypopygial forceps subconical, not as large as third antennal segment.

Length, 3·25 mm.

Type, Cairns, N. Queensland (J. F. Illingworth).

This species does not agree in all respects with any of those which have been described by Kertesz as having the abdomen with paired black spots, though it is rather closely similar to some of them in many respects.

I hope to be able to present a synopsis of the species of this genus in my next paper, but, unless there are still many species unknown to me, the genus is not so well represented in Australia as I had expected it would be, there being comparatively few in hand at present as compared with those referred to *Sapromyza* when one considers the relative representations of these genera in the Orient and elsewhere.

Family Helomyzidae.

The members of this family are distinguished by the presence of vibrissae, widely spaced costal bristles, strong preapical dorsal tibial bristle, and complete auxiliary vein and anal cell.

The larvae so far known are found in carrion and in some cases in the nests of rodents, etc.

I have seen but two species from Australia, and, strangely, one of these is identical with one occurring in North America.

Genus PSEUDOLERIA Garrett.

This monobasic genus is readily distinguished by the presence of one or two bristles on the centre of the propleura.

PSEUDOLERIA PECTINATA (Loew.).

A dark greyish species, with reddish legs. The male has the apex of the basal segment of fore tarsus produced slightly below.

Length, 4-5 mm.

Locality, Sydney, N.S.W., 23.9.24.

Genus HUTTONOMYIA Malloch.

This genus is a rather aberrant one, as the auxiliary vein is less clearly separated from first than is usually the case in this family. Some authors, no doubt, would incline to place the genus in Geomyzidae, but the preponderance of evidence points to its being a helomyzid. I erected the genus for the reception of two New Zealand species, *scutellata* Hutton, and *hudsoni* Hutton. The Australian species is readily distinguished from both of these by the conspicuously spotted wings.

HUTTONOMYIA MACULIPENNIS, n. sp. Text-fig. 6.

Female.—Head whitish-clay coloured, the frontal orbits, except at anterior extremities, ocellar spot, a mark on each side of interfrontalia laterad of the triangle, and a spot between each antenna and eye, dark brown; antennae fuscous, apex of second segment rufous, base of third white; palpi brown; a dark brown mark on postocular region at middle. Thorax clay-coloured, with three narrow vittae centrally, a spot at base of each dorsocentral bristle, and a broad irregular vitta laterad of the latter, chocolate-brown; sides of scutellum and two elongate marks on its disc dark brown; pleura with a broad dark brown vitta on upper margin and a much paler one on sternopleura. Abdomen grey, with bases of tergites brownish. Legs testaceous, entire fore femora, and apices of mid and hind pairs, dark brown, apices of fore and hind tibiae slightly browned. Wings marked with dark and pale brown as in Text-figure 6. Halteres whitish.

Each orbit with two bristles; arista plumose; cheek at anterior extremity about half as high as width of third antennal segment, higher behind; eye longer than high. Dorsocentrals 1 + 3; only one postsutural intra-alar present; scutellum elongate, rather pointed at apex, flat above, the disc setulose, with four subequal marginal bristles. Mid femur with a series of anterior bristles on apical half; mid tibia with the usual two long strong divergent preapical dorsal bristles; preapical dorsal bristles on other tibiae rather weak. Costal spines distinct, venation as in Text-figure 6.

Length, 4 mm.

Type, National Park, Sydney, N.S.W., 25.4.25.

Family Neottiophilidae.

This group has recently been elevated to family rank by Hendel. It may be distinguished from its allies by the presence of vibrissae, complete auxiliary vein, and the almost entire absence of the preapical dorsal tibial bristle.

I assign to the family the Australian genus *Tapeigaster* Macquart. Professor Bezzi has placed this genus in the Scatophagidae, but the second antennal segment is not longitudinally cleft at apex above, and the spiracles of the abdomen are not in the tergites, two characters that associate it definitely with the acalyptrate series. The developed vibrissae distinguish the group from Sciomyzidae and Dryomyzidae. The Helomyzidae have always quite evident widely spaced costal bristles, and a strong preapical dorsal bristle on tibiae.

The genus Neottiophila occurs in the larval and pupal stages in the nests of birds, generally finches and sparrows. I found about a score of puparia in a single nest of the greenfinch in Scotland in the winter of 1908. It will be of interest to discover if *Tapeigaster* occurs in the larval stages in fungi as suggested by Bezzi.

I have before me three species of the genus, one apparently undescribed.

TAPEIGASTER FULVA, n. sp.

Male.—Shining fulvous. Ocellar spot, antennae, and arista, black; frons and face along each eye margin when seen from some angles, whitish dusted; palpi and proboscis yellow. Thoracic dorsum unicolorous fulvous, with a narrow dark mark along notopleural suture. Apices of femora, a ring near bases and another at apices of tibiae, and apical three or four tarsal segments, black. Wings yellowish hyaline; tegulae fuscous. Halteres fulvous.

Postverticals convergent, a rather strong incurved bristle laterad of the outer vertical on each side; arista sparsely pubescent; face normal. Thorax as in other species. Hypopygium large, without dorsal tubercles; fifth sternite with a deep V-shaped central cleft. Femora but little thickened and with only short hairs, the fore and mid pairs with short stout black spines at apices below, those on anteroventral surface forming shorter series than the posteroventrals, the hind femora with the spines present only on the anteroventral surface apically; tibiae without long hairs, preapical dorsal bristle microscopic.

Length, 5·5-7 mm.

Type and one paratype, Botany Bay, N.S.W. (H. Petersen).

TAPEIGASTER ANNULIPES Macquart.

I have before me a series of specimens of this species from the same locality and collector as the above species.

The legs are much longer haired and stouter than in *fulva*, and the male has a pair of stout tubercles on basal hypopygial tergite.

Family Muscidae.

Subfamily MUSCINAE.

Genus GORDONIA, nov.

Generic characters.—Referable to the subfamily Muscinae. Though the lower calypter is rounded at apex it lies close to scutellum at base, and the fourth wing-vein is obtusely bent a little beyond middle of its apical section, but the bend is very pronounced, the cell being as narrow at apex as at inner cross-vein. The general habitus is much as in *Graphomyia*, but the frons is reduced to a mere line, the prosternum and propleura are bare, the pteropleura is conspicuously haired, posterior spiracle large, with a few black setulae along its hind margin; hypopleura with some fine hairs on upper margin before spiracle, and on lower posterior angle; postalar declivity bare; scutellum haired on sides; presutural acrostichals absent. Abdomen broadly ovate, basal sternite hairy. First wing-vein setulose above on basal half of its apical section, third setulose from base to near apex both above and below; auxiliary vein with some fine hairs below basally as in *Morellia*; extreme basal sclerite of radius on underside setulose; bend of fourth vein obtuse, beyond middle. Mid tibia without a ventral bristle. Lower calypter rounded, its basal angle touching base of scutellum.

Genotype, the following species.

GORDONIA FULVITHORAX, n. sp.

Male.—Fulvous yellow, shining. Dorsum of thorax with a conspicuous broad vitta in front of suture, and the sides anteriorly, whitish or golden dusted; pleura largely golden dusted. Abdomen darker than thorax, probably variable in colour, the fourth tergite golden dusted. Legs fulvous, tarsi darker. Wings yellowish hyaline. Calyptrae and halteres yellow.

Frons linear; arista plumose; third antennal segment about three times as long as second. Thorax with 2 + 4 dorsocentrals, the anterior three or four pairs short and weak; anterior postsutural intra-alar lacking; prealar present but short; sternopleurals 1 + 2. Abdomen with apical bristles on tergites short but distinct. Fore tibia with an anterodorsal series of short setulae and no posterior bristle; mid tibia with three long posterior and one or two short posterodorsal bristles; hind femur with short bristles on basal half of posteroventral and apical half of anteroventral surfaces; hind tibia with one short posterodorsal setula beyond middle, a series of setulae on basal half of anterodorsal surface, the apical one, at middle, longest, and about half a dozen short fine anteroventral setulae.

Length, 7 mm.

Type, Gordonvale, N. Queensland.

In my key to the genera of Muscinae, published in Part v of this series of papers, this genus will run down to caption 6, section two. From *Morellia* and *Pyrellia*, the two genera contained in that group, it may readily be distinguished by the fulvous colour, the others being blue-black to metallic blue or green in colour, and both have the lower calypter broad and subtruncate at apex as against the rounded and narrower form in *Gordonia*.

The female is unknown to me.

Subfamily PHAONIINAE.

Genus PERONIA Robineau-Desvoidy.

This genus is undoubtedly the same as *Australophyra* Malloch, and the genotype of the latter, *analis* Macquart, is a synonym of *rostrata* Robineau-Desvoidy.

Genus RHYNCOMYDAEA Malloch.

In my key to the Australian genera of Muscidae I did not make allowance for two segregates of this genus, one with, and one without, pteropleural hairs. The one with the hairs running to section 24 in my key separates from the other two genera included therein by the presence of a strong facial carina, neither of the others having this. It appears that this group, with *carinata* Stein as genotype, should form a new genus, for which I propose the name *Hardyia* in honour of the well known Australian dipterist, G. H. Hardy.

THE PHYSIOGRAPHY AND GEOGRAPHY OF THE HAWKESBURY RIVER BETWEEN WINDSOR AND WISEMAN'S FERRY.

By Lesley D. Hall, B.Sc., Science Research Scholar in Geography, the University of Sydney.
(*From the Department of Geography.*)

(Plates xxxv-xxxvi, and 18 Text-figures.)
[Read 24th November, 1926.]

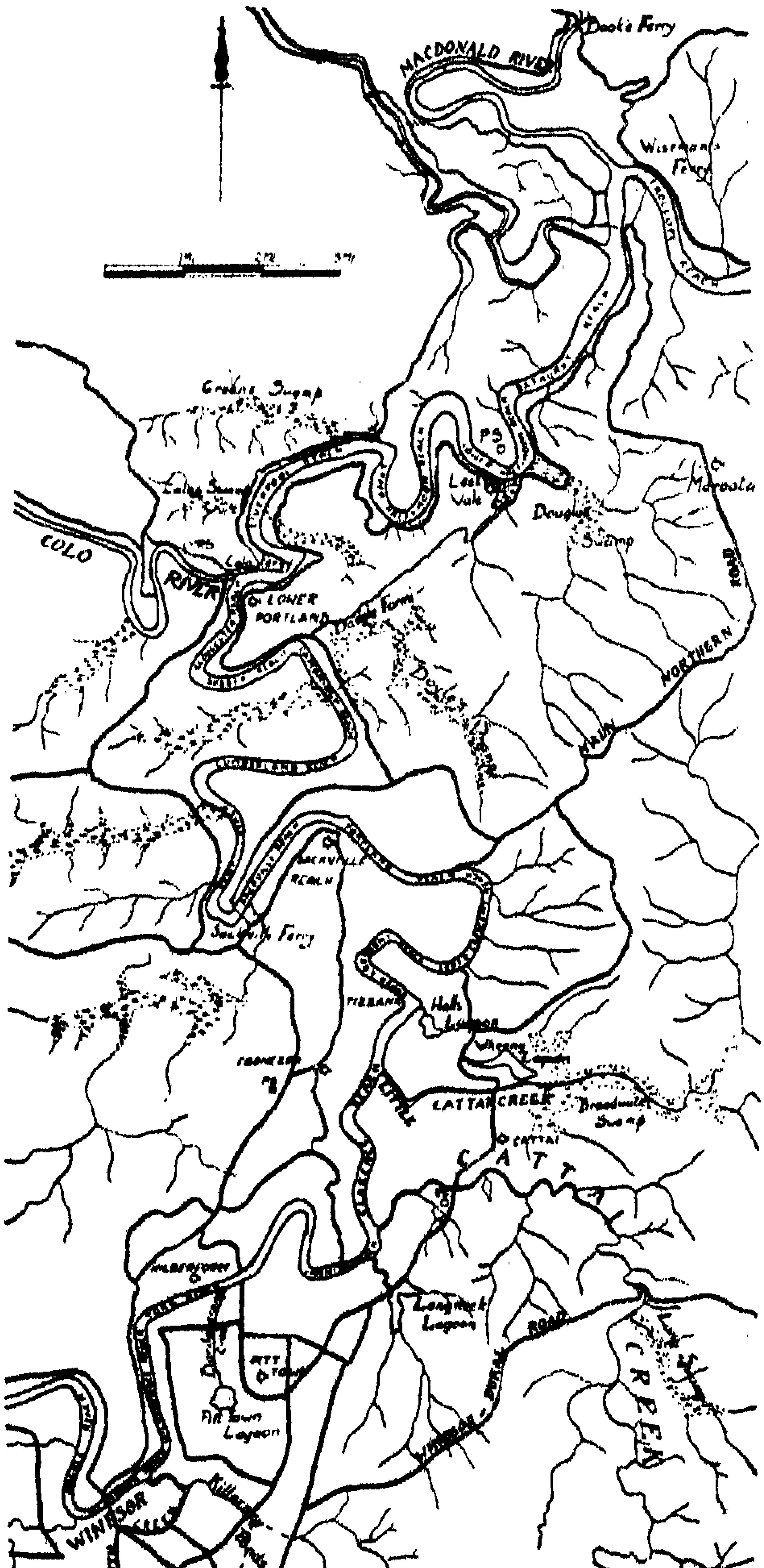
Introduction.

The work which is detailed in this paper was carried out during 1925 at the suggestion of Professor Griffith Taylor. The region investigated consists of a strip of country 18 miles long and approximately 9 miles wide, which includes the Hawkesbury River between the town of Windsor and the crossing at Wiseman's Ferry. This area, though small, is of considerable interest, for here marked changes in the physiography take place with corresponding effects on settlement.

The Hawkesbury is part of an extensive river system which surrounds Sydney and is important as the source of the metropolitan water supply. The main stream rises 20 miles from Goulburn and is known by various names throughout its course, a difficulty which originated when the early explorers gave different names to the streams they discovered, before they were demonstrated to be all parts of the one system. It flows in a northerly direction from the vicinity of Goulburn to Wiseman's Ferry and is joined by a number of large tributaries, before it turns abruptly to the east at the latter point to enter the sea at Broken Bay.

The bulk of the paper is taken up with a detailed description of the main river and the lower portions of its tributaries. Geological and ecological factors and their relation to physiography are discussed, more especially with regard to their effect on man and his means of livelihood. To demonstrate the physiographic control of settlement it has been necessary to include an historical account of man's development within the area and to discuss present day occupations, resources and means of communication.

Being so easily accessible from Sydney and lying within the Triassic basin, there is a considerable literature dealing with the geological and ecological aspects, and the early history has also been carefully studied by a number of workers. The general physiography is included by Taylor (1923*a*) in his discussion of the Sydney District, with its three warped areas and their relation to the "Wianamatta Stillstand". There has, however, so far as I am aware, been no previous work of a precisely similar nature to that dealt with in this paper.



Text-figure 1. Map of the Hawkesbury River between Windsor and Wiseman's Ferry.

History and Early Settlement.

The Hawkesbury River was first discovered in 1789 by a party under the leadership of Governor Phillip, who was anxiously exploring the district in the vicinity of Port Jackson in an effort to find land suitable for immediate cultivation. In that year the river was navigated as far as Richmond Hill, where the large expanse of fertile silts put an end to Phillip's fear that the young colony would fail through lack of food. He saw the advantage of such good land on the banks of a large river which afforded easy communication with Sydney, but he felt that a settlement scheme could not be carried through with convicts. Concerning this he wrote in a dispatch: "The Hawkesbury River will, no doubt, offer some desirable situations, and the advantages of a navigable river are obvious; but before a settlement can be made proper people to conduct it must be found and we must be better acquainted with the country. Settlers may be sent there hereafter, but then we must have small craft to keep up communications". Phillip named the river after Charles Jenkinson, First Earl of Liverpool, Baron Hawkesbury, and then President of Council of Trade and Plantations. The original native name has two modern versions, "Venrubbin" and "Deerubbin".

When Phillip left the colony, the administration fell into the hands of Lieutenant-Governor Grose, who settled 22 farmers on the banks of the Hawkesbury and South Creek in 1794. These 22 men, the names of whom are still on record, are generally accepted as the first people to colonize this district; but there is also a record of a certain Peter Hibbs, who, being one of the exploring party with the Governor, was granted land near their camping site, which he is supposed to have settled about four years earlier than the men appointed by Grose. Apart from this, it is known definitely that land was taken up near South Creek and downstream towards Wilberforce in 1794, and one year later the settlers and their families numbered 400, while their farms extended for 30 miles along the river. The details and a map of these early grants are given by Campbell (1925). By 1796 the fertile lands were yielding large crops and the district of "Green Hills" had become the granary of New South Wales.

The blacks were very troublesome and made it necessary for a detachment of the New South Wales Corps to be stationed in the locality. Floods of the river were also disastrous, causing great discomfort and often loss of life to the settlers whose holdings were completely in the lowland. Moreover, often the crops of wheat were destroyed, resulting in a shortage of food throughout the colony. Such was the state of the settlement for the first fifteen years of its establishment; conditions which led to Macquarie's public order of 1810, by which the established five towns on the higher land to act as places of refuge in time of flood. An extract from his order explains this necessity: "The frequent inundations of the rivers Hawkesbury and Nepean having been hitherto attended with the most calamitous results with regard to crops growing in their vicinity, and in consequence of most serious injury to the necessary subsistence of the colony, the Governor has deemed it expedient to erect certain townships in the most contiguous and eligible high grounds in the several districts subjected to those inundations, for the purpose of rendering every possible accommodation and security to the settlers whose farms are exposed to the floods". The five townships thus selected were Windsor, Richmond, Pitt Town, Wilberforce and Castlereagh. Each settler was given an allotment of ground in the town site sufficient for his house and proportional to the amount of farm land he held within the

flooded area; while large granaries were built in the townships, where wheat and maize were stored under Government supervision.

After its foundation in 1810, Windsor developed rapidly into a fairly large town and entered upon its period of maximum importance. By Macquarie's orders, roads were constructed and kept in order by a toll system, public buildings were erected and officials appointed. A complete record of this stage in its history has been written by Steele (1916), and other details concerning the development of the town are given by Hendy-Pooley (1906). Windsor of to-day, with its numerous old buildings gradually falling to ruin, is but a slumbrous relic of a tumultuous past, when military force was necessary to control a mixed community of convicts, emancipists and free settlers who prospered on hard work and plain food and lived, many of them, to great ages.

The town of Wilberforce was built at the same time and developed along lines similar to Windsor, but at Portland Head a different settlement was made. The land in this vicinity was taken up by a number of free settlers who came out from England on the "Coromandel" and were granted the large holdings on either side of the river which are to-day still farmed by their descendants. It was these people who built the famous Presbyterian chapel at Ebenezer (Plate xxxv, fig. 1). "The sturdy Hawkesbury farmers cut the stone on their own land, each his allotted share, felled the timber in the bush and fashioned it for its particular place and duty; and from the time when they began in 1802 to the day of its completion in 1808, they worked and carted and built, until they achieved their object and raised the church at Ebenezer, which stands to-day as a monument of the industry and piety of the simple farmers of the early days of the Hawkesbury" (Watson, 1906). The church was opened in 1809 and was undoubtedly the first Presbyterian church to be built in Australia. It is also claimed to be the oldest church of any denomination still being used for worship.

The historical interest at Wiseman's Ferry is centred mainly in what is now an hotel, but was once the home of Solomon Wiseman, after whom the ferry was named. He was placed in control of 300 convicts who were sent to the Hawkesbury district to build quarters for the officials and to construct roads. Much of their work is still to be seen in the quaint houses built of sandstone blocks which have stood for over 100 years. They also built the great wall which carries the road down the side of the hill to the river, where the ferry was established by Wiseman in 1830. The first punts for the crossing were purchased by the Government in 1832. Along the convict built road are two caves, one on either side of the river, known as the "Courthouse Cave" and the "Judgement Rock" respectively, where the convicts were tried and sentenced.

While superintendent of convicts, Wiseman amassed great wealth and was able to build his famous home on one of the most beautiful sites throughout the entire river; but his treatment of his men was terribly harsh, so that to this day the old hotel is popularly supposed to be haunted by the uneasy ghosts of the victims whom he had murdered. The unhappy conditions under which the convicts lived has been described by White (1906). In return for assigned service, the settlers were required to feed and clothe the men, who were given maize to grind for themselves when working hours were over. The mills were owned by settlers who had sufficient money to erect them on their land. The ruins of one of these old flour mills are still to be seen on Surgeon Arndell's estate at Cattai.

In the vicinity of Wiseman's Ferry the early pioneers had their farms along Webb's Creek and the Macdonald River. The former owes its name to one, J. Webb, a seaman of the first fleet, and one of the first settlers to take up farm sites along the Hawkesbury. Both streams show evidence of early occupation in picturesque houses of wattle and daub or sandstone blocks. Near Book's Ferry on the Macdonald is the ruin of St. Joseph's Church, which was built in 1839 of sandstone blocks with a shingle roof, but was destroyed by fire over 30 years ago.

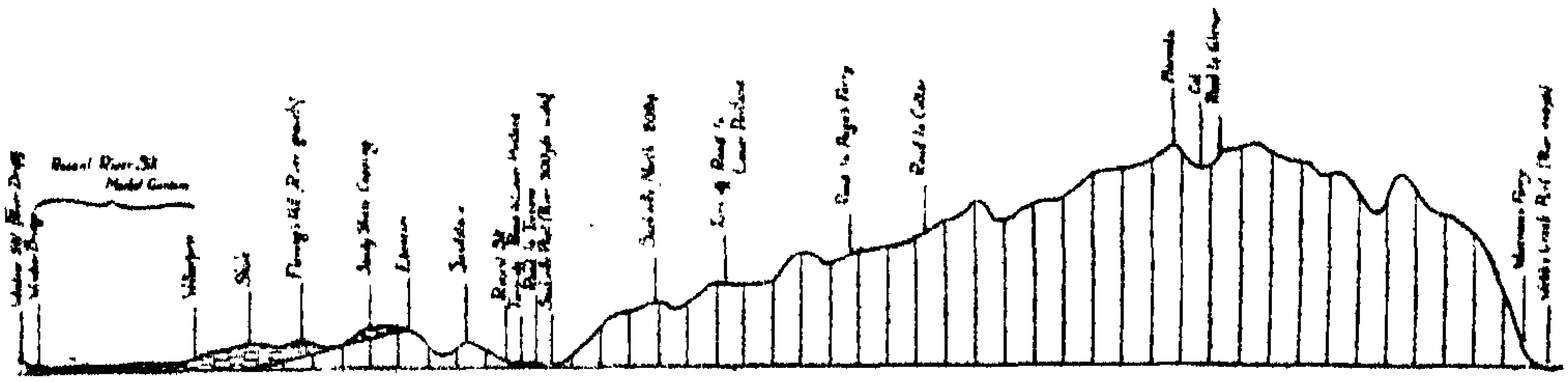
For about 20 years after the opening up of the Hawkesbury River in 1794, settlers crowded into the region round Richmond, Windsor and northwards, until every existing area of silt land was occupied. During that time the district was able to supply all the food necessary for the colony; but its resources were definitely limited and its period of importance of but short duration. With the growth of settlement, larger and better grazing lands were demanded, with the ultimate result that the Blue Mountain barrier was crossed and the western plains made available. When this occurred, the expanding population crossed the mountains to new farm lands and the Hawkesbury district was left as a small oasis of population, not far from the main city, yet completely isolated by barren sandstone hills. Throughout the years it has offered no inducement to new settlers, for its limits were reached in the early days, so that the present farms are in many cases original land grants, the present houses are old ones erected, often, 100 years ago, and the present inhabitants are descendants of the early pioneer stock. Intermarriage has long been common, especially to the north, and, among a population originally descended from a mixture of convicts, half-castes and free settlers, has resulted in many cases in a decreasing mental efficiency. Finally, many of the younger generation are leaving the district, so that a population, already weakened by inbreeding, is fast becoming further impoverished by the loss of its most energetic members.

General Survey of the Area.

In general, the outstanding feature of the area is a region of low relief to the south, rising gradually northwards to a level of about 700 feet. This arrangement gives a natural division into three topographic areas, each of which is described in detail below. The first of these divisions is formed by the southern basin of flat country, bounded to the east and west by low rounded hills, through which the river flows in wide senile meanders. To the north, the flood plain of the river gradually becomes narrower, the hills close in on either side, while the relief generally is more pronounced. This is the second, or intermediate area and contains the line of change from lowland to highland. The third division is marked by rugged uplands, dissected into deep juvenile gorges by innumerable small streams. In this region the river, which still maintains its meandering course, is deeply entrenched, and a typical feature is the occurrence of trough-shaped valleys. These are not valleys formed by trough faulting, but juvenile gorges eroded during a previous cycle, which are now filled in at the base with silts.

Within the district, the river is flowing from south to north and in so doing it flows from the region of subdued topography into the highlands through which it has cut its way to the sea. From such an arrangement it is obvious that the course of the river was established before the mountain bar was formed, and that uplift was slow enough to allow the river to keep pace with it and so maintain its original course. The general slope of the inclined peneplain surface

is from 50 feet above sea-level at Wilberforce, to 712 feet at Wiseman's Ferry, a rise of 660 feet in 22 miles or increase in height of 1 in 176. The profile section from Windsor to Wiseman's Ferry is compiled from aneroid readings over a period of one and a half hours and shows the flat surface between Windsor and Wilberforce followed by the gradual rise to the highland beyond.



Text-figure 2. Aneroid Profile Section along the main road from Windsor through Sackville to Wiseman's Ferry. Scale: Vertical 1 inch = 1,000 feet. Horizontal 1 inch = 5 miles (approx.).

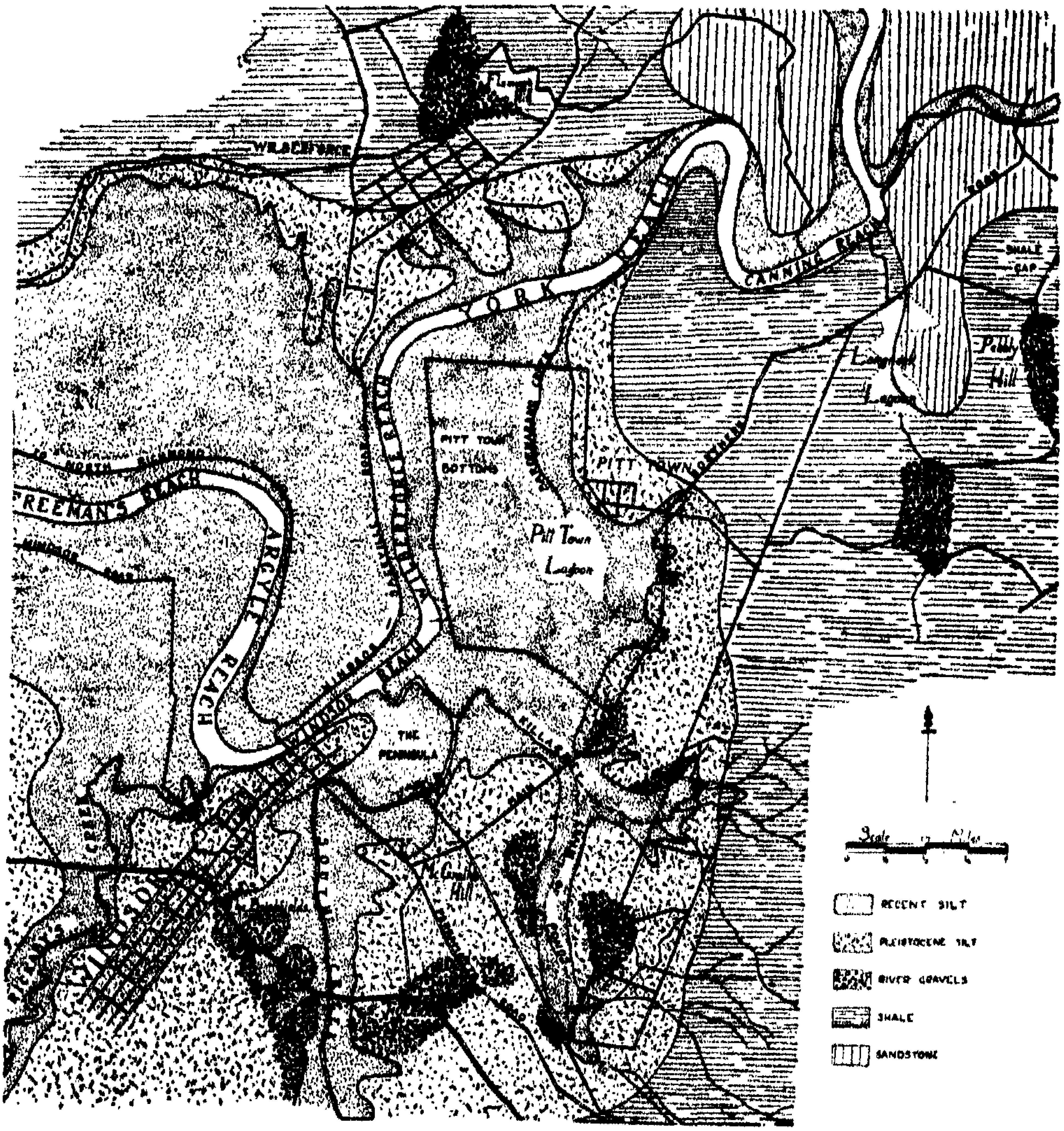
$$\frac{V}{H} = \frac{26 \cdot 4}{1}$$

Within the area there is little geological variation. The strata are part of the Triassic basin of the Sydney district, and consist of freshwater beds of shale alternating with sandstone, which overlie the Permo-Carboniferous formation in three stages. Of these the Wianamatta shale series is at the top, but where uplift has taken place, they have been worn away, exposing the Hawkesbury sandstone series beneath. Hence the Wianamatta shale is now limited to the southern portion of the area which has not been uplifted, while the remainder is Hawkesbury sandstone. Beds of the Narrabeen stage are absent, but at Wiseman's Ferry, where the height of the warp is over 700 feet, the river in cutting through has exposed, at the base of the sandstone, a series of shales which mark the transition between Hawkesbury and Narrabeen strata. These shales, on the northern side of the Wiseman's crossing, are present in a series of alternating brown and dark grey bands. The dark bands are fossiliferous and yield specimens of *Thinnfeldia*. In the vicinity of Windsor there is an extensive development of river silts. These belong to two different cycles, for the recent silts which form the flood plain of the present river have been deposited 30 feet below the level of the older alluvials. These latter form banks of reddish soil with which are associated outcrops of river gravel. The gravels are similar to other outcrops occurring between Penrith and Windsor (Jensen, 1911) and the pebbles are hard and siliceous. Crushed specimens, obtained from the Yarramundi Gravel Works, show that the gravels consist mainly of granite, granite-porphyry, quartz-porphyry, quartzite and slate.

Ecology.

The absence of complex geological structures in a region where rainfall and other climatic considerations are fairly uniform, has resulted in a general similarity of local vegetation types. There are, however, distinct differences in the plants which flourish on the silt, shale and sandstone soils; while within these main groups are minor variations due to aspect, with its dependent differences in humidity. In the lowland region of recent river silts, the vegetation has been cleared away to make room for artificial cultivation. The only natural area is a

strip of land 100 feet wide on either side of the river, which has been preserved from alienation by the Government in order to minimize the risk of land slides. In this strip, the vegetation is zoned according to proximity to the river. In the patches of silt which are gradually encroaching on the channel, are the long



Text-figure 3. Map of Windsor district showing Pleistocene and Recent Silts and the location of the river gravel outcrops. Geological boundaries approximate.

reeds, *Thypa*, and sedges, Cyperaceae, growing partly submerged in the water but with their upper portion exposed to the air. The first row of trees along the bank is formed by the willows, *Salix* sp., which grow right at the edge and have their branches dipping into the water. Behind these are the she-oaks, *Casuarina*

sp., tall, fine trees, with blackberries (*Rubus*) and other creepers growing in the silt around their base. The third line of trees, the black wattles, *Acacia decurrens*, grows back on the grassy flat. These three types are always to be found on the river bank growing in the same relationship to each other. Farther north *Cassia* sp., was also observed growing on banks of river silt, while *Leptospermum* sp. had commenced to colonize the sandy river flats.

On the undulating hills of the southern lowland, the vegetation is stunted and scanty and there is no definite zone dividing the soil in which the gravels are imbedded and the soil from the Wianamatta shale. They both support a growth of small eucalypts with stunted shrubs of the paper-bark tree, *Melaleuca* sp., but no undergrowth. This ground has also been cleared extensively and the grassy paddocks are used for stock. In the uplifted region of Hawkesbury sandstone, the vegetation has been left practically untouched, since the soil generally is considered too barren for cultivation. It supports a growth of various species of eucalypts and a typical xerophilous flora composed of members of the Proteaceae, Epacridaceae, and Leguminosae. The occurrence of individual species varies according to physiographic position. Along the top of the sandstone ridges the vegetation is unprotected from the wind and most of the moisture is quickly drained away, so the trees are smaller and more stunted. This is particularly noticeable in the highly dissected areas where the ridges are narrow, and innumerable boulders prohibit the growth of undershrubs, except for clumps of tufted grass and a few straggling flowers. Where the ridges are wider, sandy soil collects and is inhabited by practically all the common flower types. The chief eucalypts in this location are the apple, *E. stuartiana*, grey gum, *E. propinqua*, pepper, *E. piperita*, some stringybark, *E. obliqua* and *E. eugenioides*, a few ironbark, *E. leucoxylon*, and others of universal distribution throughout the area. The ironbark is a very important and valuable timber tree, but in this locality the trees are not abundant or large enough to cover the expense of milling. Of the other timbers, the Grey Gum is most useful, since it is a durable timber used by the settlers for fencing posts.

On the side of the ridges the vegetation is thicker, flowers are commoner and are found associated with the bracken fern (*Pteris*). Clumps of grass trees (*Xanthorrhoea australis*) form a conspicuous feature. On the slopes the effect of aspect on the vegetation is very marked, for the main river is so curved that the tributary streams strike in at all angles and the valley walls face in every direction. Where the slope is exposed to the winds bringing rain from the south, the humidity is high and plants are able to grow luxuriously in spite of inhospitable soil. Typical examples are the cliff faces on the northern side of Sussex Reach and the bend in the river immediately to the north of Colo Junction. On such slopes other ferns besides the bracken were observed growing on the sandy talus and extending up towards the sandstone cliffs where wet weather streams gave ample supplies of moisture. Flowers were quite abundant and among them *Gompholobium grandiflorum*, Acacias of various species, *Indigophora australis*, *Kennedya rubicunda*, *Grevillea* sp., *Lambertia formosa*, *Hibbertia fascicularis*, *Dianella revoluta*, *Diuris* sp., *Styphelia tubiflora*, and numerous other Epacrids were noted. The timber was composed of *Eucalyptus* species similar to those mentioned above with some *Angophora* and *Casuarina* sp.

Where the cliffs were exposed to the west, as in part of the Lower and Upper Half Moon Reaches, the difference was clearly marked. Here the humidity is absorbed by hot dry winds in summer and cold dry winds in winter, so that

the slopes are almost barren. There were few flowers except for some hardy Proteaceous types such as *Lomatia* sp. and *Isopogon* sp., and the timber was mainly composed of associations of tree Banksias, *B. integrifolia*, with an undergrowth of *Xanthorrhoea*. The easterly slopes are sheltered from the wind and exposed to the sunshine and were characterized by an abundant growth of flannel-flowers, *Actinotus helianthum*, and *Boronia pinnata*. The trees were also much larger. With a northerly aspect the plants are sheltered from both wind and sun and such shady positions were marked by fewer flowers than were found on the east and south. An interesting feature on slopes of this nature, which had plenty of moisture draining down into a main stream, was the occurrence of groves of she-oaks, *Casuarina* sp. On other sheltered slopes in the centre of the sandstone district the timber was interspersed with growths of lignum vitae. This tree is an Acacia which is similar to brigalow and has a very hard wood of cedar-like grain combined with the grooved exterior of the ironbark. The trees do not grow to any great size and the timber can therefore only be used for small articles such as picture frames.

In the small juvenile gullies the vegetation is varied by shade-loving trees such as the Waratah, *Telopea speciosissima*, and the Christmas bush, *Ceratopetalum gummiferum*. At the head of the trough valleys, where the silt floor has as yet been uncleared for cultivation, the timber is taller and the more valuable trees are to be found. Woollybutt, *E. longiflora*, Bloodwood, *E. corymbosa*, and Forest Red Gum, *E. tereticornis*, are fairly common throughout the gullies, while in isolated cases Blackbutt, *E. pilularis*, and Turpentine, *Syncarpia laurifolia*, occur. The first three types yield strong and durable timber which is useful for posts and piles and for wood paving (Maiden, 1896). The blackbutt is invaluable for this latter purpose, while *Syncarpia* secretes resin by which it obtains a certain immunity from pests; it is useful for joists and pillars, as it will withstand the attacks of cobra, *Teredo navicularis*, in sea water. In most of the gullies the undergrowth is dense and is composed of *Melaleuca* and other allied types. Bracken grows thickly with other ferns along the creek bed, but flowers are not so numerous. North of Wiseman's Ferry the creeks have cut their way down to the shale beds between the Hawkesbury and Narrabeen series and the plants are therefore growing on richer soil. In these gullies the vegetation is more luxuriant, forming outposts of the northern brush forest. Ferns grow thickly and the tall spikes of the giant lily, *Doryanthes excelsa*, make bright spots with their clusters of red flowers. The trees include *Syncarpia*, the native beech, *Callicoma serratifolia*, the silky oak, *Grevillea* sp., and the giant Christmas bush or coachwood, *Ceratopetalum apetalum*. These softwoods are finely grained and are useful for cabinet making.

Detailed Description of the Main River.

The Hawkesbury River flows from Windsor to Wiseman's Ferry in a series of meanders so deeply curved that, whereas the distance between the two places is 25 miles by road, for a boat the journey is just twice as long. It was formerly senile throughout its course, but, as the hills were gradually formed to the north, so the meanders became more deeply entrenched. In this uplifted region areas of silt have been built up at the foot of the sandstone spurs on the inner side of the meanders. These flats occur all along the river on opposite sides according to the swing of the current and have partially filled in the broad channel which was originally cut in the sandstone. It is obvious that at one time the stream filled

the channel from ridge to ridge and the silts were deposited beneath the surface of the water on the convex side of the meanders, where the current was not strong enough to wash them away. The recent exposure of the silts may be due either to uplift or to a diminution in rainfall which has produced a smaller stream. The tributary valleys have been affected in the same manner, but here in many cases the silts have completely covered the valley floor and appear to have been deposited in a quiet backwater rather than a running stream. Their evidence thus tends to confirm Taylor's views on the physiographical development of the Hawkesbury River, which he describes as follows (Taylor, 1923a, pp. 18-21): The original course of the river was determined by the flat Wianamatta surface over which it flowed in a series of senile meanders with broad mature valleys. During the period of uplift which followed, all the valleys within the warped area were affected, the streams were rejuvenated and deep gorges eroded. Then a downward oscillation occurred, the Hawkesbury Valley was drowned and a marine canal produced which extended inland almost as far as Windsor. In this canal large quantities of silt were deposited which gradually filled up the valley, except where a channel was cleared out by the swing of the current. The final stage was a small recent uplift exposing the silts which almost filled the original valley.

This would account for the areas of silt in the tributary valleys as well as for those along the main river. Where the stream is tidal, sediments brought in by tributary streams are still being deposited beneath the surface, so that, if another small uplift were to take place, the river would be even more limited. A decrease in rainfall over the catchment area of the Hawkesbury River has been noted for the last 50 years and has resulted in the drying up of some of the tributary streams, but has not markedly affected the main tidal channel.

At Windsor the tide is merely a banking up of the freshwater which moves so slowly as to be almost imperceptible. At Yarramundi, four miles farther south, the river is known as the Nepean and is a freshwater flowing stream, so the Hawkesbury river is that part of the main stream which is tidal. After a very wet time the water is fresh almost to Wiseman's Ferry, but, as the season progresses without rain, the salt makes its way up the river. At Leet's Vale and Lower Portland the water is always salt during the summer and during a very dry season it becomes brackish at Sackville. At Windsor the water remains fresh at all seasons and is used to supply the town.

The width of the river is variable, from 120 yards where it is crossed by the Windsor Bridge, to about half a mile at some places in the more northerly reaches. In this upper portion the river channel is wide and deep and the tidal effect is strong enough to scour the silts away from the concave side of the meanders. Wherever there is an area of still water, however, the sediments are deposited to form sand-banks, bars and beaches. These are often found on the point of exposed river flats. Near Windsor the movement of the tide is weak and, except at flood time, its scouring effect is negligible, so that great banks of sand have been formed almost filling up the channel. A narrow passage is left in places, but the action of flood waters has been to distribute the silts across the river bed, and below the bridge the water is now so shallow that navigation is difficult, even for rowing boats. Sediments are also added by Little Cattai Creek and South Creek which have built long spits of sand at their points of junction.

Thus the river, being at base level throughout its course, is mainly aggrading its bed, but in the northern reaches lateral erosion is still fairly active on the concave side of the meanders. In the reaches exposed to strong winds, the water

is often blown into waves whose erosive power is sufficient to form sandstone caves at water level. In other places, although the joint planes form lines of weakness in the strata, the erosion is not very active except during the descent of tempestuous flood waters, and is insufficient to account for the occurrence of the river flats as a factor of a widening meander belt (Davis, 1909), as might be the case in a more vigorous river.

Description of Tributary Streams.

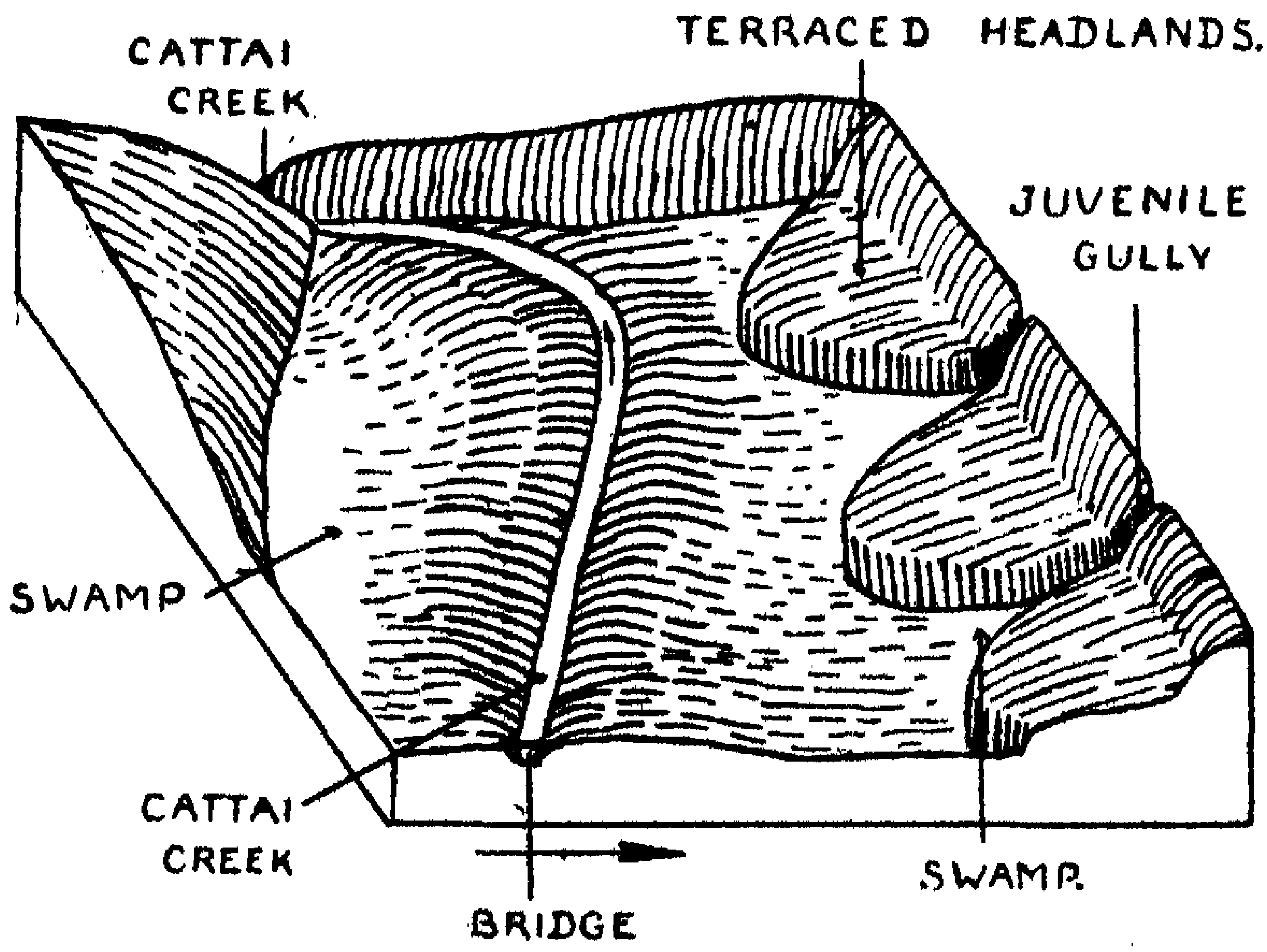
Within the 50 miles the river is joined by tributaries with extensive headwaters. The larger streams are tidal in their lower portions and have been subjected to the same series of changes which affected the main river in the past. The smaller tributaries have ceased to exist as flowing streams, and form the flat areas of internal drainage here termed "trough valleys" because of their distinctive cross section. Some juvenile tributaries have come into existence since the last disturbance and, although most of them are only active during wet weather, they form the network of deep gullies which gives the uplands their characteristic dissected facies.

Macdonald River.—One of the largest of the tributary streams is the Macdonald River which has its source on the southern scarp of the Hunter River Valley and, flowing south through sandstone country, joins the main river at Wiseman's Elbow. At its mouth the Macdonald is a senile tidal channel about 150 yards wide, meandering through the river silts which form the flat base of its sandstone valley. The water is salt, except during very wet seasons. The headwaters of the stream drain a different area from those of the Hawkesbury, so the tributary may not be in flood at the same time as the main river. When the Macdonald does flood it is very destructive, for it deposits only sand and thus lessens the fertility of the river flats. During floods of the Hawkesbury the water backs up the Macdonald, leaving some mud, so that nearer the mouth of the river the flats are richer. Dairying is the main occupation of the farmers, who grow crops on the flat land as feed for their cows. In the upper part of its course, where the scouring effect of the tide is not strong, the stream is rapidly becoming blocked by sand bars. The trading boat is able to navigate the stream for about 8 miles from its mouth if it takes advantage of the tide. At St. Alban's, which is 10 miles from Wiseman's Ferry by road, the river bed is entirely filled with sand, the only water present being a chain of ponds (Plate xxxvi, fig. 4). This marks the limit of the tidal portion of the river. Above St. Alban's it is a freshwater stream.

Cattai Creek and the *Colo River* are streams whose development has been similar to that of the Macdonald. The latter is the longest of all the tributaries with a watershed 1,500 sq. miles in extent. It flows into the Hawkesbury about 12 miles above Wiseman's Ferry and the settlement at its mouth on both sides of the river is known as Lower Portland. At its mouth it is 120 yards wide, forming a channel only navigable for four miles at low tide owing to the sand spits which extend almost across the river. At high tide there is sufficient water for the boats to penetrate nine miles inland. The Colo is a tortuous stream with meanders deeply entrenched in hills 400 feet high. Within the meander curves are long sandstone spurs, sloping gradually down to the river silts which have been piled up against the swing of the current to form areas of flat land. The river in flood brings mud from the coal measure series, as well as sand, and so tends to renew rather than to destroy the fertility of the flats. These silt soils and conditions

generally in the Colo Valley are well adapted to agriculture and the chief products are maize and citrus fruits; the summer fruit is impracticable owing to its perishable nature and the unavoidable delay in transport. Many farmers have settled miles beyond the point to which navigation is possible, and have to cart produce and provisions to and from the cargo boat, which steams up and down the river three times a week and connects with the main steamer for Sydney.

Cattai Creek has a variable valley section since it drains both shale and sandstone country. It has its source near Quaker's Hill in the Wianamatta area, and is joined by a number of tributaries as it flows north to where, leaving the region of low relief, it turns to the west through higher land and forms a series of incised meanders, before joining the Hawkesbury at the southern end of Clarence Reach, nearly two miles above the Little Cattai junction (Text-fig. 1). Within the uplifted area the stream is similar to the more northerly ones. The creek is about 25 yards wide and is embedded 4 feet below the surface of a silt plain a quarter of a mile wide, which is the flat floor of the trough valley. The valley walls have been dissected by juvenile streams and a distinctive feature is the resulting headlands in which the sandstone is terraced (Text-fig. 4). As its



Text-figure 4. Block diagram of a small area where the northern road crosses Cattai Creek, showing silts, flood levée, swamp and terraced headlands.

$$\frac{V}{H} = \frac{3}{2}$$

position is at the beginning of the warp the hills are only 50 feet near its mouth, though farther back they rise to 100 feet. The creek is, therefore, a consequent stream, flowing with the slope of the warp and for this reason it has joined the main river in a distinct boat-hook bend. The creek is tidal as far back as Long Swamp, which is about four miles from its mouth, but is not used by cargo boats to any great extent. In the tidal portion sediments are deposited by the active

headwaters and sandy spits and beaches encroach on the channel, while reeds grow in the silt on either side of the creek.

The Long Swamp is a low marshy area of internal drainage which joins the main stream at right angles. It represents a tributary whose course has been blocked by recent uplift. The creek itself has not been affected in the same manner, but has had sufficient water to cut a new valley through the silts deposited in the bed of the original stream. Above this swamp region the creek is in shale country. Its valley widens out into an area of undulating topography, where the more open land supports a few homesteads. Near its mouth there are also farms along the valley, but in the middle section of the creek the rugged physiography prohibits settlement, and the silts are covered with a dense growth of bracken and tall trees.

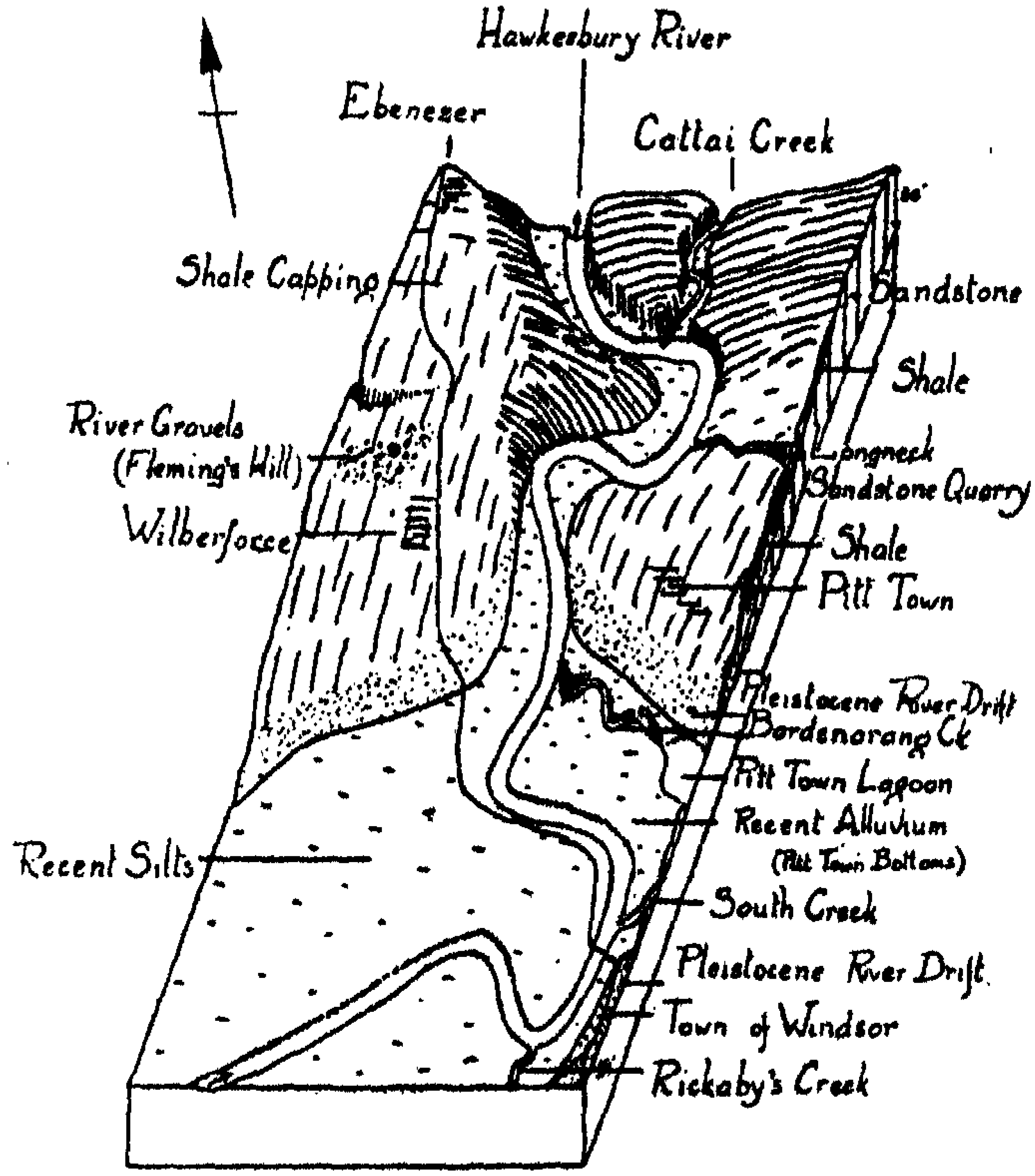
Webb's Creek and *Little Cattai Creek* are smaller senile streams flowing over the silts which have filled in the base of the sandstone valley. The former enters the main river three-quarters of a mile above Wiseman's Ferry (Text-fig. 1), where it is only 20 yards wide. The limits of navigation are reached within the first five miles, where the creek becomes a mere trickle in a sandy bed. It gradually peters out as the valley becomes more and more filled with sand. Its total length in wet weather is only 15 miles. Even at its mouth, where the tidal effect is fairly strong, silts are encroaching on the channel and support a growth of long reeds at either bank. The course of the creek is apt to suffer change under the pressure of flood waters and the flats are losing their fertility owing to deposits of sand. Farm land is still used for orchards and dairying, but no new areas are taken up and the whole settlement is drifting backwards. The sandstone ridge which separates the Macdonald Valley from that of Webb's Creek is narrow and has been almost breached in one place where there is now a pass of 200 feet below the main peneplain level. A good road over this pass across the ridge serves to connect the Webb's Creek settlements with those of the Macdonald River.

Little Cattai Creek enters the Clarence Reach of the Hawkesbury River almost opposite the locality of Ebenezer. From its source on the southern side of the Maroota Ridge, it flows almost due south for about five miles in a wide flat gully and receives numerous tributaries on both sides. It then turns west and at the bend is joined by Kelly's Arm Creek which comes from the south in a similar trough-like valley (Text-fig. 1). As the river turns to the west, it opens into the marshy area known as Broadwater Swamp which is similar in origin to the other "trough valleys". About two and a half miles from the mouth of the creek the land becomes higher and the silts on the sides of the stream are used for maize cultivation. As in the case of Webb's Creek the present stream is merely a gutter, 10 feet wide, which has cut a meandering course through the silts forming the flat base of its wide sandstone valley.

South Creek and *Rickaby's Creek* are two small tributaries which join the main stream, one on each side of the Windsor peninsula. They have both cut their way through the level of the Pleistocene River gravels in that locality. Near its junction with the main river, South Creek sweeps to the east and then turns west in a wide semi-circle, thus cutting off an isolated area of higher lands known locally as the "Peninsula" (Text-fig. 3). The river is here flowing through some of the richest farm land of the district and is joined in wet weather by the Killarney Chain of Ponds which also dissects the Pleistocene alluvials. In dry seasons Rickaby's Creek is merely a chain of ponds which meander to the river through banks of silt 25 feet high.

DETAILED PHYSIOGRAPHY.

The marked change in the physiography between Windsor and Wiseman's Ferry is due to the northern warp which has affected part of the area, while leaving the rest unchanged. The hinge of uplift is in the vicinity of a line through Wilberforce and Pitt Town. The physiography may therefore be divided into three regions having each their own typical characteristics and yet merging gradually into each other.



Text-figure 5. Diagrammatic representation of the Hawkesbury River north of Windsor, showing the change from lowland to highland.

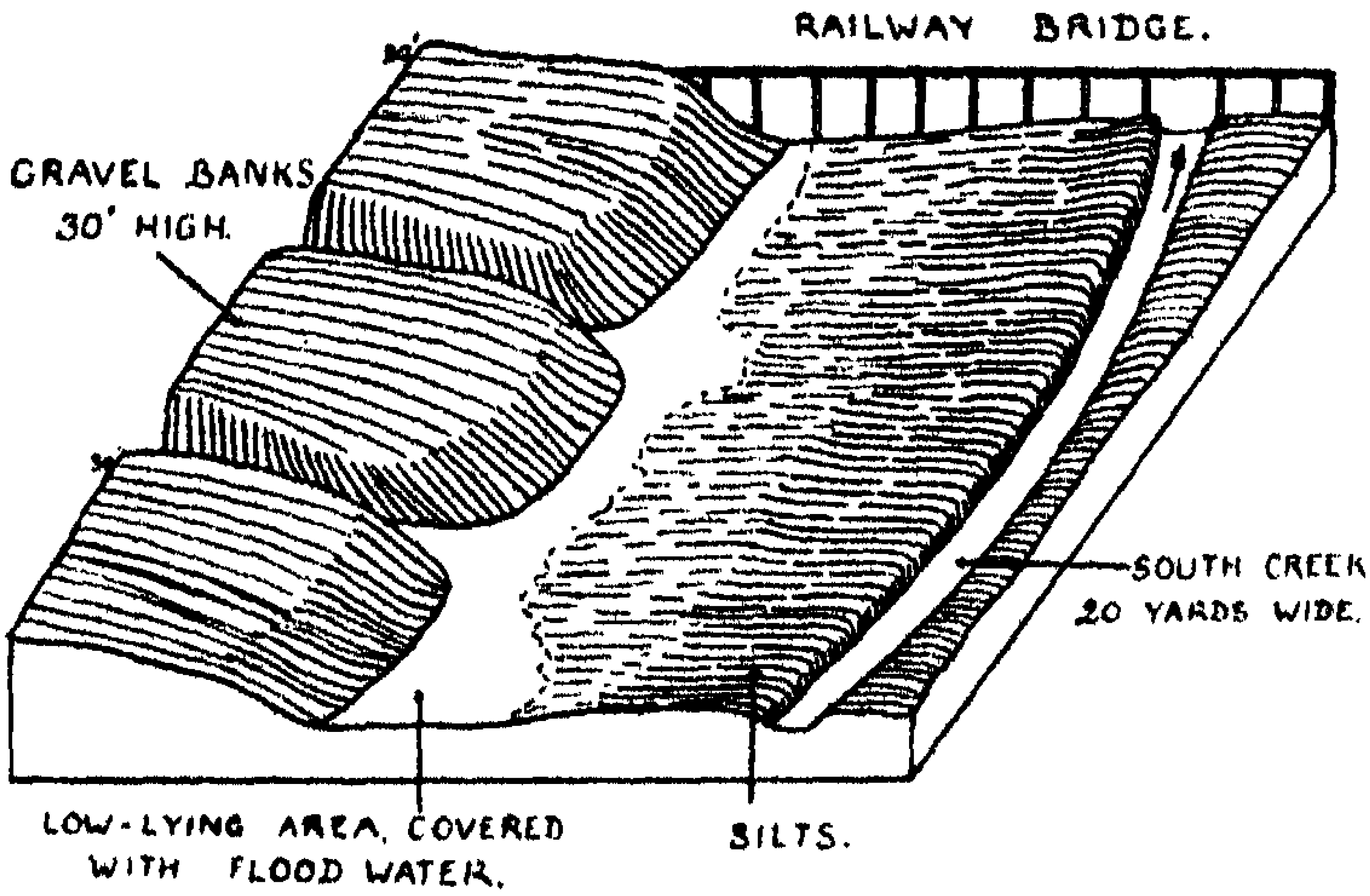
$$\frac{V}{H} = \frac{26}{1}$$

Flat Stillstand Region.

Windsor town is built on a peninsula of red sandy alluvium about 50 feet above the level of the surrounding river flats. The flats are the recent flood plain of the river and consist of a fertile loam subdivided into many small farms and market gardens. The Windsor Peninsula is part of what was once an extensive alluvial plain, but is now thoroughly dissected by the Hawkesbury and its tributaries, South Creek and Rickaby's Creek, which have formed the lower plains of recent silts along their banks. The recent silts of the Hawkesbury are about three miles wide in the vicinity of Windsor and extend along the river as far back as Penrith. The towns of Richmond, Clarendon and Windsor are built on the old high-level alluvials which give place gradually on the eastern and

southern sides to the rounded grassy hills of the Wianamatta shale country. To the north and west the change is more abrupt from the raised shale slopes to the dissected sandstone hills of the northern and western warps.

Associated with the high-level alluvials, there are, in the vicinity of Windsor, several outcrops of river gravel. The gravels consist of water-worn pebbles, varying greatly in size, from one inch to eight or ten inches in length, embedded in a matrix of fine red sandy soil and occurring in a series of isolated outcrops always 30 feet or more above the level of the present river. The pebbles are very siliceous and consist mainly of quartzites and porphyries. To the west of Windsor town, in a cutting east of Cornwallis's Bridge over Rickaby's Creek, is a gravel outcrop eroded by the stream which has numerous pebbles in its bed. In the town itself gravels are common, but may have been brought there for use in street building and are not definitely known to be *in situ*. On the eastern side of Windsor Peninsula near the railway line are the old brickfields, where clay was obtained for building in the early settlement days, and here are large deposits of gravel in the alluvium which has been eroded by South Creek. The gravels here form banks 30 feet above the level of the recent silts and extend both north and south of the railway line.



Text-figure 6. Block diagram of part of South Creek to the south of the railway bridge at Windsor, showing recent silts and gravel banks.

$$\frac{V}{H} = \frac{8}{1}$$

On the other side of South Creek the gravels are found in a similar position, extending past Mulgrave Station back to the Parramatta Road. At McGrath's Hill no gravels are visible, but eastward, towards the hills, where the older silts have been eroded by the Killarney ponds, are located the several outcrops shown on the map (Text-fig. 3).

The origin of these various gravel outcrops is not precisely clear and they offer an interesting field for more detailed work. Coarser silts and rounded pebbles are associated with a juvenile and actively eroding stream, whereas, in the time preceding the Kosciusko period of uplift, the Hawkesbury was presumably

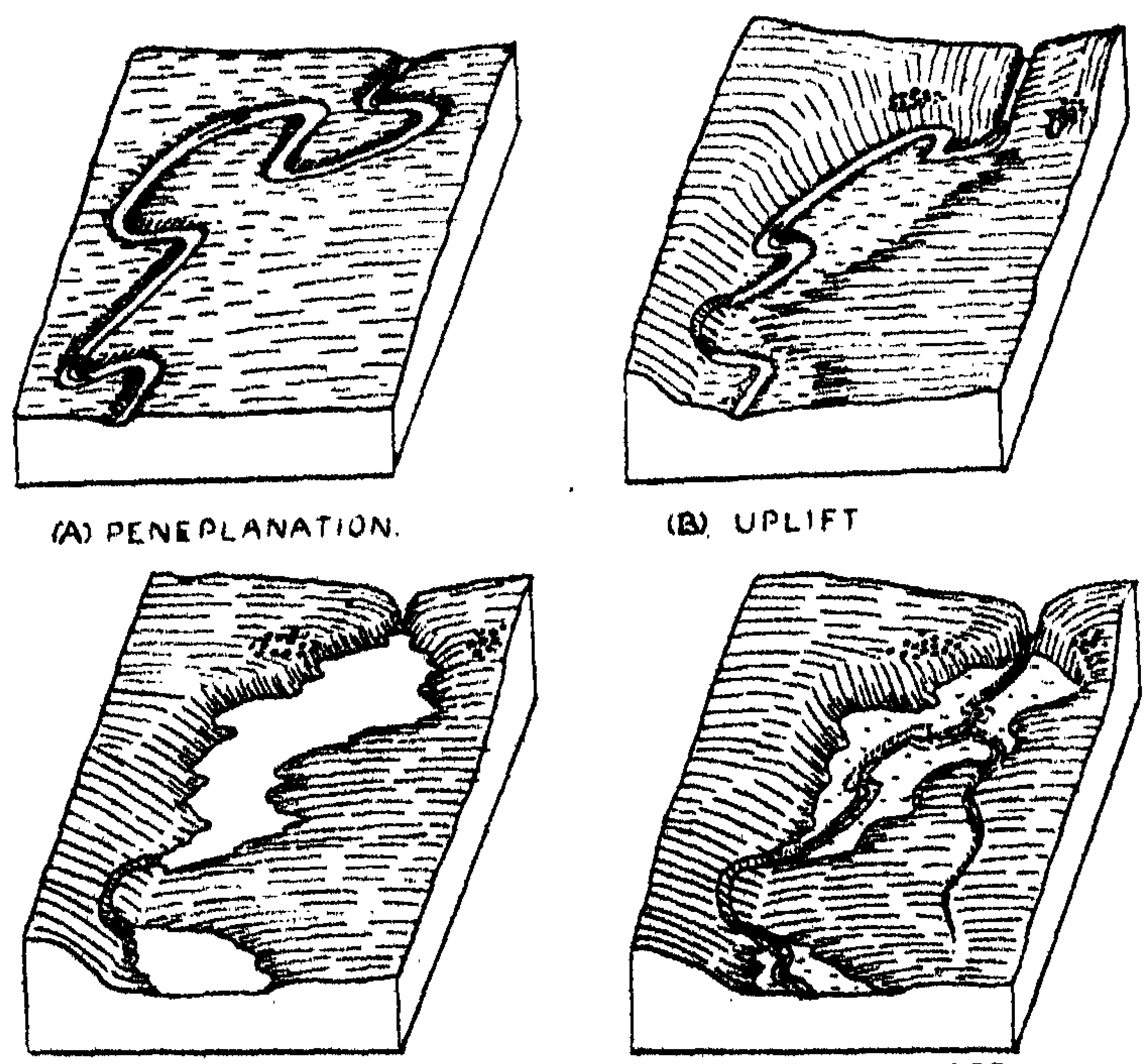
a senile river flowing in a north-south direction over a peneplain surface. The structure of the gravels shows that they were originally derived from the Wollondilly region of quartzites and igneous rock types. They may be shown to be of similar age and origin to the gravels of Barber's Creek between the Wollondilly and the Shoalhaven (Woolnough and Taylor, 1906). The gravels were formed in a juvenile stream during the period of erosion by which the peneplain was produced, and at the beginning of uplift were present in the bed of the stream, which by that time was in the senile stage of development. The position of the present gravel outcrops and their association with the high level silts are factors of the changes which occurred during the period of uplift and development of the three warped areas.

Jensen (1911) reviews the outcrops of river gravel between Penrith and Windsor and their association with the older alluvials, which he states to be of Pliocene or Pleistocene age. He concludes that the line of gravels marks the position of the old senile river, which was caused to move to the west by a movement of depression in the area round Richmond, following on the monoclinal fold of the Blue Mountains. The high level alluvials he discusses in these terms: "The vast stretch of poor sandy soil between the old gravels and the alluvials of recent age is of drift origin . . . . and may indicate a shifting of the river from its ancient to its present course. They are light sandy loams, partly the product of river deposition when it was changing its bed and partly redistributed silt washed down from the old bed now represented by gravel hills". This explanation seems hardly adequate to account for such an extensive plain of alluvium as must have once existed, nor does it account for the succeeding erosion of that plain by the modern river. A senile river which is constantly changing its course would naturally be easily affected by a period of uplift, but in the Windsor district this action appears to be combined with a temporary lake formation as described by Taylor (1923*c*). The interaction of the two factors to produce the present physiographic arrangement might be accounted for in the following way:

In late Tertiary times the Hawkesbury was a senile river winding north over the Wianamatta plain (Text-fig. 7, A). With the Kosciusko period of uplift, the western warp commenced cutting through some of the meanders of the river, with the result that half the meander was uplifted while the other half remained stationary or was, perhaps, slightly depressed. To the north, also, uplift occurred, cutting right across the course of the river which was for some time able to erode its valley as fast as it was uplifted (Text-fig. 7, B). At one time, however, a slight depression of the land in front of the uplift occurred, with the result that the river was no longer able to cut through the northern warp and was blocked to form a lake (Text-fig. 7, C). This lake, which extended from where the river leaves the western warp at Penrith to where it enters the northern warp at Cattai, formed a temporary base level and in it all the silts from the rapidly eroding mountain streams were deposited. Finally the water in the lake became high enough to overflow through its former notch and so the stream continued to cut down its former valley to sea-level (Text-fig. 7, D). The waters of the lake were thus drained off and base level lowered, so the new river and its tributaries commenced to erode the flat area of exposed silts. The original stream was obliterated by the lake, but the pebbles which were in its bed remained there in association with the silts and so have formed the gravel outcrops to be seen in the Windsor district to-day.

Intermediate Region.

Past Windsor for two or three miles the river meanders through its recent flood plain, which becomes narrower as the northern uplifted area is approached. Here the Wianamatta shale persists as a small area of undulating country with sandstone exposed to the north and a remnant of the Pleistocene alluvials overlying the shale to the south (Text-fig. 5). All three formations have been cut through by the river. On the hills of Wianamatta shale on the western side of the river, the town of Wilberforce is built, while Pitt Town is located in a similar position on the eastern side. At Wilberforce (Text-fig. 3), the recent silts form a narrow strip along the river bank occupied by citrus fruit orchards. Behind them is the undulating area of older alluvials, used mainly for grazing, which



Text-figure 7. A series of four block diagrams illustrating the physiographic development of the Windsor district.

give place quickly to the shale uplands, where the churches, school and most of the houses are built, well above the level of the highest flood waters. The northern road to Sackville passes from recent silt on to Pleistocene alluvium and then on to the shale, which persists as a thin capping as far north as Ebenezer. Past Ebenezer the land slopes down to the river at Sackville (Text-fig. 2), and here the sandstone outcrop is definitely revealed.

Immediately to the north of Wilberforce, near Fleming's Hill, in shale country and well above the level of the old river alluvium, is an extensive outcrop of river gravel (Text-fig. 5). The pebbles are very numerous, well rounded or egg-shaped, varying from a fraction of an inch to ten or twelve inches in length embedded in a fine friable soil of dark brown colour. Some of the smaller pebbles

are composed entirely of milky or rose-pink quartz; some of the bigger ones are quartzite and others are of igneous origin. The outcrop is about 100 feet above the level of the river and has been dissected by the present drainage. On the gravel slopes orcharding is carried on, for, although the soil is very difficult to plough, it is rich enough to pay for the trouble.

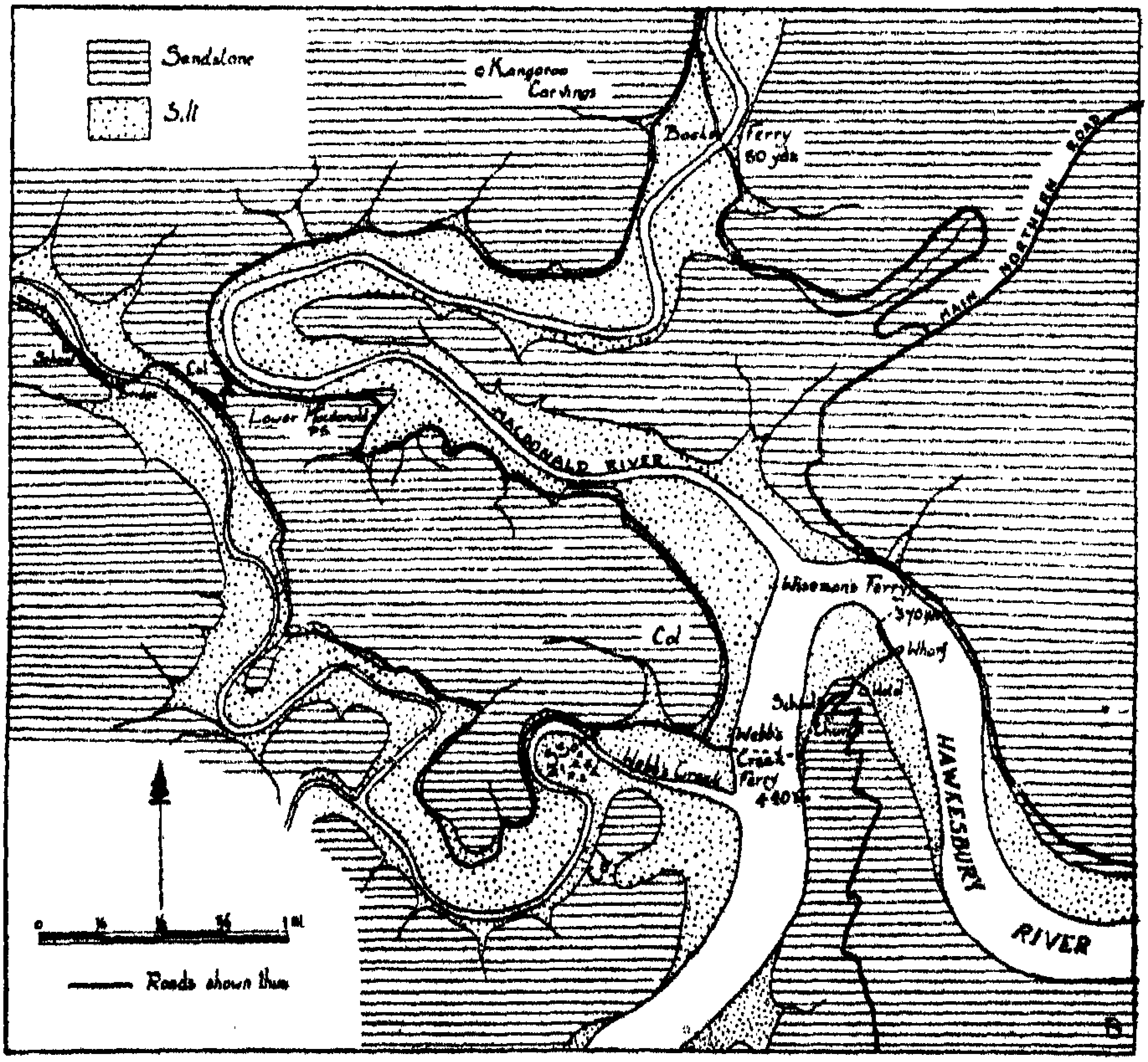
Between Windsor and Pitt Town the Wianamatta shales and Pleistocene alluvials have been eroded by South Creek and the Killarney Ponds, so that on this side of the river there is an extensive development of river silts. Between Pitt Town and the river there is an area of rich river flats, two miles long and one mile wide, known as the Pitt Town Bottoms. The town is built on a ridge 50 feet above river level which is composed of Wianamatta shale and Pleistocene alluvials. At the foot of the ridge the silts are low, but they rise gradually towards the river. The low lying region is covered by Pitt Town Lagoon, an area of water which varies greatly according to the season. The lagoon is drained by Bardenarang Creek, a narrow gutter which has cut through 20 feet of silt at the river bank and which acts more as an inlet for water during flood than as an outlet at other seasons. From Pitt Town onwards, the shale forms a thin capping over the sandstone on the undissected ridges as far north as Cattai. River erosion, however, causes the sandstone to be exposed and the first outcrop along the river bank occurs about half-way between Longneck Lagoon and Cattai Creek. This lagoon is nearly half a mile back from the river and the streams forming its headwaters have cut through the shale and exposed the sandstone, which is here quarried for use in road making.

To the east of Longneck, on a shale-capped ridge over 100 feet above the level of the river, occurs the most northerly outcrop of the river gravels. These water-worn pebbles are similar to those of Fleming's Hill in the number of small ones composed entirely of quartz and the associated soil of brownish colour. The outcrop is not wide, though about 700 yards in length, and has been dissected on both sides, with the sandstone outcrop not far below the gravel. To the south is another and similar area of brownish soil containing river gravels. It is dissected by one of the streams which flows into Longneck Lagoon. The soil is easily eroded and the water has cut a wide flat valley, washing out the pebbles and depositing them in its bed, which is composed of soft sticky clay instead of the usual sand. These gravel outcrops are similar to each other and to those of Fleming's Hill and yet are different from those found in the vicinity of Windsor. Their height above present river level is much greater and they are not associated with the reddish silts of the high level alluvials in which the Windsor pebbles are embedded. The northern gravels are situated practically on the hinge of uplift, where the original senile river would be affected to the greatest extent.

With the rise of the land to the north and west, the river may have been moved slowly from the hills of Wilberforce and Pitt Town to the position it occupies to-day. This alteration occurred before the formation of the Pleistocene Lake. The river had, therefore, cut its notch lower than the old gravels, so that the waters of the lake were able to drain away before its silts were built up high enough to affect these outcrops as they did those nearer Windsor (Text-fig. 7, D). These gravels within the warped region mark a period when the river flowed in wider meanders than at the present day, but their very elevation has subjected them to the erosion which makes it difficult to trace the position of the original course.

The Uplifted Region.

This third region is by far the greatest in area for it includes all the country to the north of Cattai. The structure is that of a peneplain which has been tilted along a definite hinge line, so that, though the general surface is even, the height increases steadily towards the north. Since its uplift the peneplain has been attacked by numerous streams and their effect, combined with that of the rejuvenated rivers, has been to cut down the original surface into hills and valleys, thus giving a typical rugged topography. It is now only on the dividing ridges that any of the level surface is left and along these the main northern road has been built.



Text-figure 8. Map of the Wiseman's Ferry district showing the sandstone ridges and the areas of silt along the banks of the rivers. Based on field sketches.

Cols.—An interesting feature of the area is the occurrence of saddles or cols at various places in the sandstone ridges. They are well below the general height of the main spur and form marked breaks in the peneplain level. One of the largest of these saddles is formed on the ridge between Webb's Creek and the Macdonald River. The height of the spur is 600 feet and the col, 200 feet lower, forms a convenient pass for the main road between these two places. Just on top

is an outcrop of micaceous shale which, from its position, would seem to have had a determining influence on the saddle development. Such depressions are common throughout the Wiseman's Ferry area where the hills are fairly high, but they seem to develop most readily in those places which have been narrowed by dissection. Where long sandstone spurs extend into the meanders, there is nearly always a col developed at the top, which is the narrowest place between the arms of the curve. Such cols bear a significant relationship to the development of the beheaded meanders described in a later section.

Trough Valleys.—Another very striking feature within the uplifted region is the wide distribution of trough valleys, narrow gorges with high sandstone walls and a flat floor of river silt, which have been cut back into the hills for distances varying from three or four miles to a few hundred yards. The valleys were originally formed by vigorous juvenile streams which attacked the peneplain at the time of uplift and were able to cut the lower portion of their beds down to the base level of the river. When the drowning occurred these gorges were inundated as far back as the head of active erosion, and in this manner the mouths of the streams were converted into areas of still water into which the silts from the unaffected portions were discharged. The main river also added its quota of sediment to these quiet backwaters, helping to fill in the original bed of the stream, so that the water became increasingly shallow. The small secondary uplift was then sufficient to reveal these silts as a narrow strip of flat land at the base of the hills. In some cases all the water was drained away, but in others, such as Little Cattai and Webb's Creek, a small stream was left. Gullies of this type are common all along the river, from which they are separated by a bar of higher land. This bar is formed of recent silts deposited at flood times and is gradually being built higher and higher, with an abrupt rise up from the river and a gentle slope on the landward side down to the flat land beyond. When flood waters rise, they are able to pass over the bar and inundate the valley, but, unless there is artificial drainage, the water cannot escape and so lies on the surface until it gradually dries away.

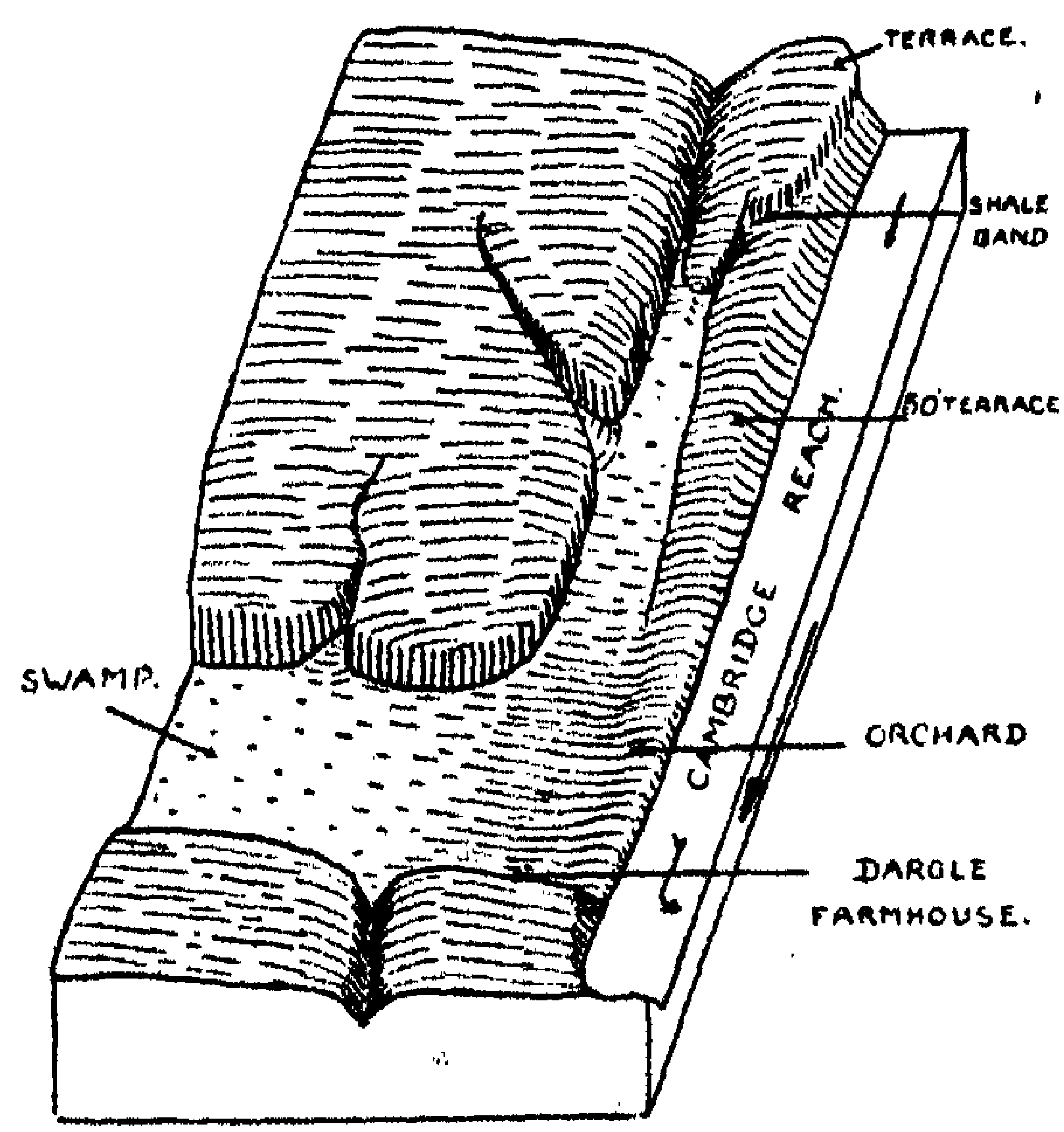
The low-lying portion of the valley is often quite swampy in character, as the trough-like areas form basins of internal drainage for all the streams which are now dissecting the valley walls. When these streams come to the abrupt change in grade, their velocity is checked and they drop their sediments. These silts form a series of small alluvial fans along the valley walls at the base of every juvenile gorge. The water from these streams either lies about on the surface of the flats, or else sinks underground through the silts and makes its way slowly to the river. In one of the smaller gullies a well dug in the silts yields, at a depth of three feet, water which is always fresh and has never been known to dry up.

The longest of the trough valleys is at the northern end of Liverpool Reach and is known as Green's Swamp (Text-figure 1). Two others occur at the southern end of the Reach, but the largest of all, by reason of its many tributaries, is the one at the northern end of Cambridge Reach which has Dargle Farm at its mouth. Another large one joins Cambridge Reach from the western side. The village of Leet's Vale is named from the trough valley where its post office is built, and, not half a mile to the north of this one, is the long gully farmed by Mr. Douglass (Pl. xxxv, fig. 2). This swamp has a number of headwater streams and the flat area is drained by a creek ten yards wide. Similar valleys occur as tributaries of the Colo River and to the south are two large ones draining into Kent and Sackville Reaches. These, and the trough which is drained by Little

Cattai Creek show the greatest development, but all along the river are smaller valleys of the same character.

It is noticeable that most of these gullies are at right angles to the main river, while the valley walls are fairly linear and the tributaries strike in at angles closely approximating 90°. This regular arrangement may be dependent on the rectangular nature of the jointing in the Hawkesbury sandstone. A river attacking an uplifted surface naturally follows along lines of weakness, so that jointing, while causing alterations in the course of the antecedent stream, may also have affected the course taken by the new tributaries. The trough valleys are all very much alike, but the height of the enclosing wall varies according to the amount of warping which has taken place in that particular area and other minor differences occur.

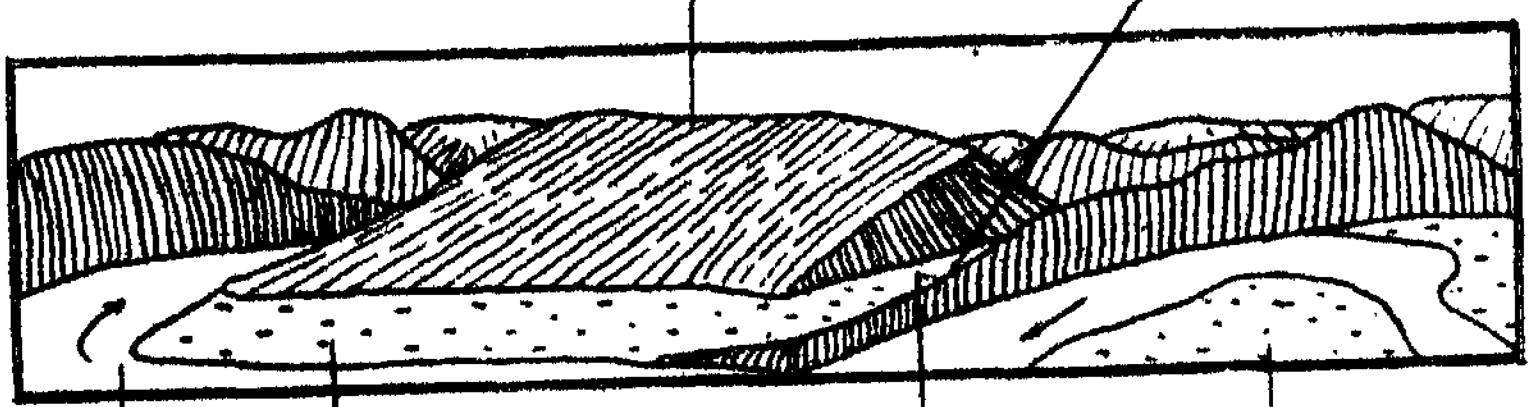
Dargle Farm swampland has very many small tributaries, in each of which the valley narrows and finally ends in a juvenile stream with a rocky bed of sandstone and boulders which form wet weather waterfalls and cascades. The most



Text-figure 9. Block diagram of Dargle Farm swampland at its junction with the Hawkesbury River.

northerly of these tributaries ends in a narrow sandstone ridge, which is all that separates it from a similar gully extending northwards and widening out into the flat swampland of Leet's Vale. The ridge is only about 400 feet high and, where the road joining these two places crosses it, the sandstone has been weathered, forming a col below the general plateau level. Where the swamp joins the main stream, a tributary valley runs parallel to the river, beginning as a juvenile valley in the ridge 300 feet high and opening out into a swampy flat nearly one mile in length from its junction with the main trough. At the base of the ridge a band of micaceous shale has caused the overlying sandstone to be eroded back for

about a quarter of a mile. In this way a sandstone terrace 50 feet high has been made, which forms a spur 200 yards long separating the river from the swamp (Text-figure 9). A similar structure has been developed by the gully opposite Eales' Swamp, which is entrenched for nearly two miles back into the hills and has hardly any headwater streams. On the southern side the valley is separated from the river by a narrow sandstone spur and, as the current on that side is swinging in against the cliff, the water may ultimately cut its way through leaving an isolated sandstone knob.



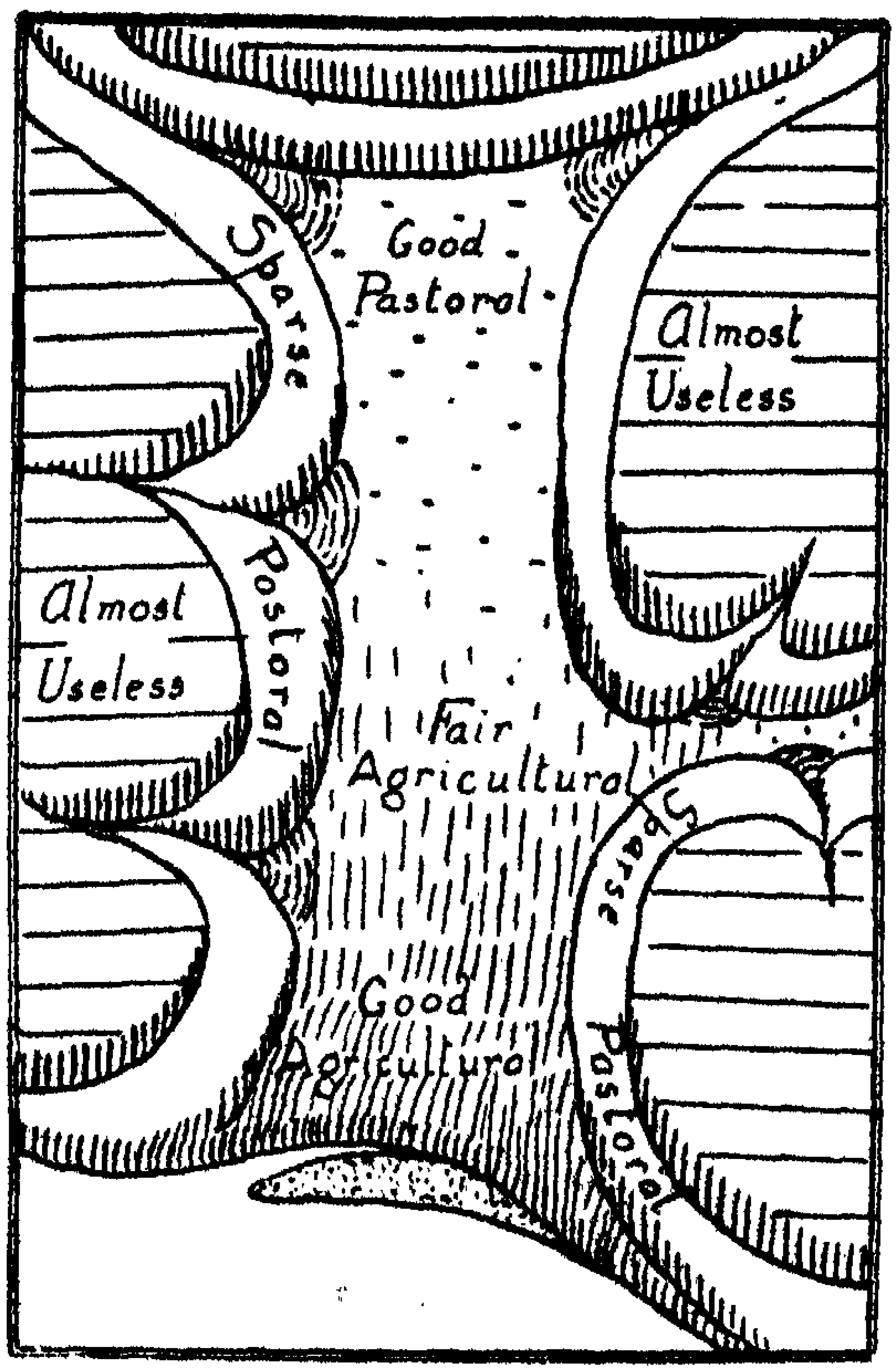
Text-figure 10. View of the hills on the eastern side of Liverpool Reach showing the narrow spur which may ultimately be breached by the river.

The trough valleys are a splendid example of man's dependence on physiography, as their occurrence is of the utmost importance in the economy of the district. The rugged uplands of barren sandstone are inhospitable to mankind, and it is only the small areas of good soil afforded by the river flats and these silted valleys which make the region at all habitable. Wherever the silts have collected they have been farmed and the result is a population scattered along the river in homesteads about half a mile apart nestling at the base of sandstone hills. Where an area occurs which is sufficient to support more than one farm, the cluster is known as a village. Some of the gullies only offer a very small area for cultivation. Sand eroded from the surrounding hills threatens to overwhelm these small farms, and the occurrence of a flood is always welcomed because of the fertilizing mud which is deposited.

In the long trough valleys, the physiographic arrangement has resulted in the development of the same five economic regions into which Taylor (1923*b*), working on a climatic basis, has divided Australia. The high sandstone ridges are "almost useless", except where they are wide enough on top to give a sandy soil in which oranges, peas, and passion-fruit can be grown if sufficient fertilizer is used. The trees which grow here are of no practical use, except as timber for fence posts. On the side of the hills the sandstone is terraced and the soil is sufficiently good to grow some grass during the spring and autumn, and cattle are grazed there during those seasons. On these terraces, which represent the "sparse pastoral area", the homes of the farmers are built. The three other natural regions are on the flat valley floor. The river levée consists of rich loam, well drained and constantly fertilized by floods; its agricultural value is appreciated by the farmers who have planted it with fruit trees. On the landward side of the levée the soil is also good, but not so well drained, and is more likely to be covered by flood water. This is the "fair agricultural region" and is usually planted with crops of maize. Farther back up the gullies is the "good

pastoral area", for here the ground is low and moist and, although very wet in winter, it gives a luxuriant growth of grass which continues all through the summer.

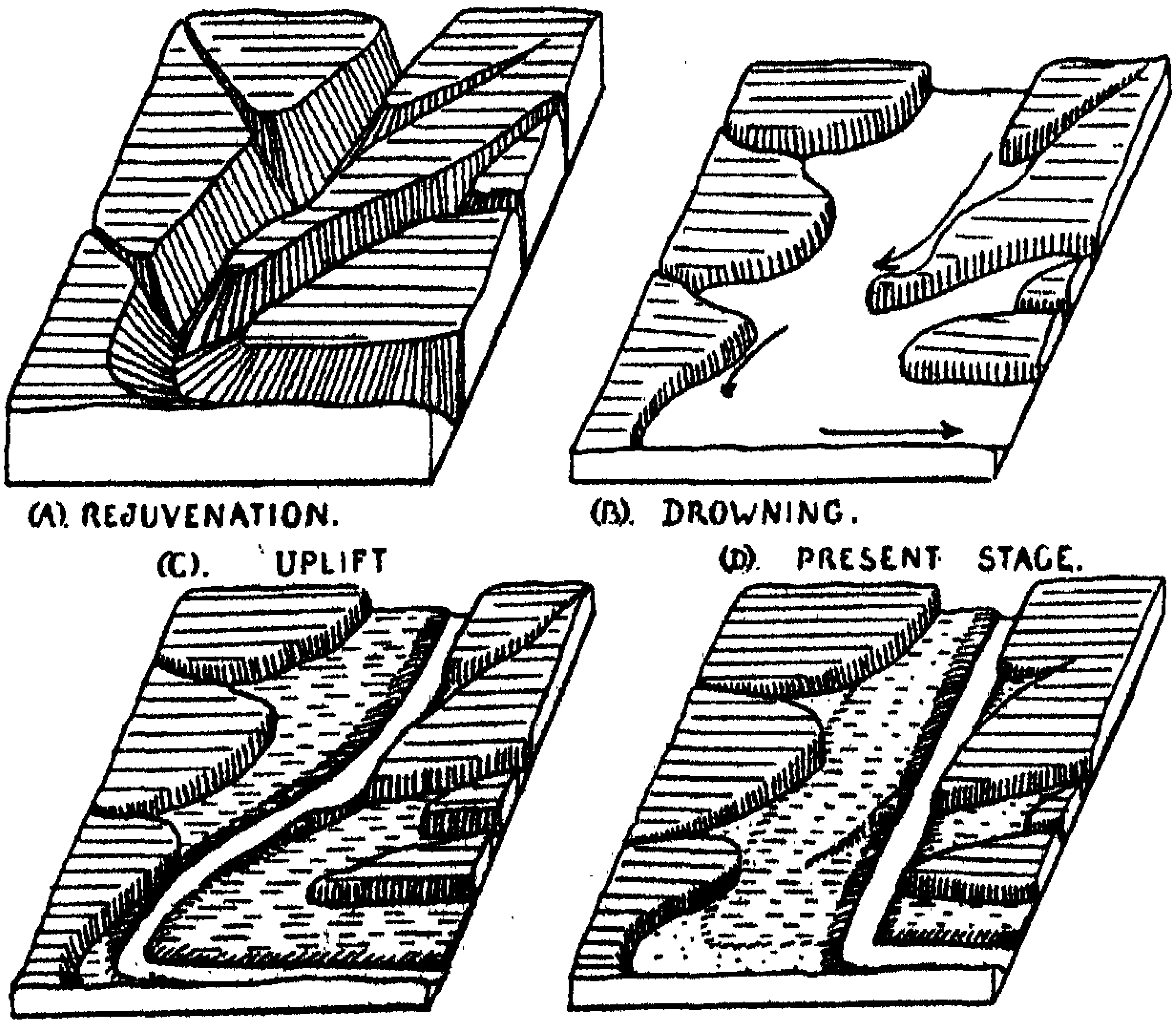
Entrenched Meanders.—The entrenched meanders of the river in the northern portion of the area have a more angular facies than is usually associated with curves developed by a sluggish stream. As has been indicated, this is due to the rectangular jointing in the Hawkesbury sandstone, which impressed some of its characters on the river during the period of erosion. Long straight reaches and right-angled bends, such as are typically seen at Sackville, are the result. In this



Text-figure 11. Diagrammatic representation of the natural regions in a typical trough valley. (Based on regional diagrams by I. Bowman, 1916.)

district the river flows to the north-west, with hills 150 feet high on the left and river flats on the right, and then turns at right-angles into Sackville Reach, where the current swings to the opposite side, so that the flat area has developed on the east. This place is known locally as "Mud Island" and its most interesting feature is a small sandstone knob which forms a cliff 100 feet high and 150 feet wide on the northern side of the river (Text-figure 12, D). It is surrounded on the other three sides by river silts, 500 yards wide, between the knoll and the northern ridge. Behind the knoll the silts are piled up forming a low bank

which may possibly have sandstone as a basis, although the outcrop is not visible except at the knob itself. Along the river bank is the usual levée, but at the base of the hills the land is low and swampy and the farmers' homes are built either on the knoll or back on the main sandstone ridge. This ridge has been dissected into spurs separated by typical trough valleys. On the southern bank of the river is the flat valley where Dr. Fiaschi has his vineyard, which divides the ridge into two spurs. The isolated knoll is opposite the more easterly spur and, from a point of vantage on the hills at Sackville North, it is easy to see that these two were once joined. When such was the case, the river must have made its way through the silts, a condition which not only explains the formation of these flats, but gives a reason for the band of low swampy land at the base of the ridge.

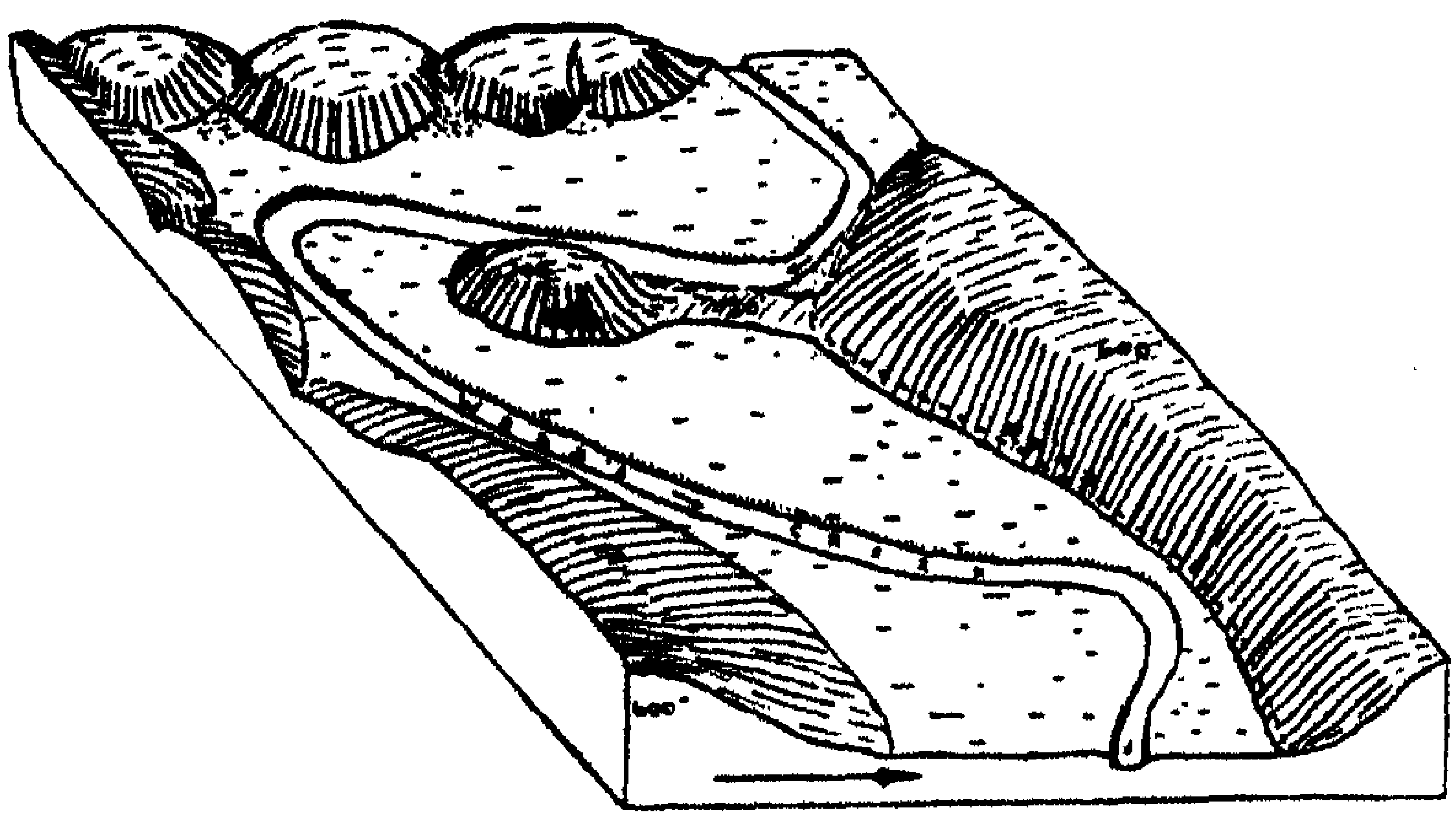


Text-figure 12. A series of diagrams representing the physiographic development of "Mud Island" in the Sackville district.

The following is a surmise as to the history of the development of this area. At the time of uplift the river became entrenched in a curved juvenile gorge with tributaries on either side, one of which joined the river near the middle of the bend on the inner side, thus cutting the spur into two parts (Text-figure 12, A). With subsidence came drowning and the water filled the whole valley of the river and penetrated back into the tributary gullies (Text-figure 12, B). Under these conditions the eastern side of the divided spur had water to erode it on each side and was also exposed to the force of the current sweeping round the curve. Assisted no doubt by joint planes of weakness in the sandstone, aerial denudation and the water were able to cut into the spur, forming a low col, while at the same

time the angular corners of all the spurs were smoothed off. Uplift followed, exposing the silts which had been deposited in the drowned valley. Through these silts flowed a new stream of smaller dimensions than the original, which followed the course of the current and continued to erode the neck of the spur (Text-figure 12, C). At this time aerial denudation was also a potent factor and gradually the obstruction became lower and lower until it was possible for the river to break across during flood times. In this way the neck was completely cut through and by carving its way through, the river assumed its present more direct course (Text-fig. 12, D). Since that time the building of the river levée has taken place and has blocked out part of the old river channel. The remaining portion is shown by the swampy area.

Webb's Creek at Cross's farm, four miles above its junction with the Hawkesbury, resembles closely the third stage described in the development of "Mud Island". Here the hills are higher, 600 feet, but the original river valley, marked by an expanse of flat grassland between the hills, is in the form of a meander closely curved upon itself. The spur dividing the meander consists of a sand-

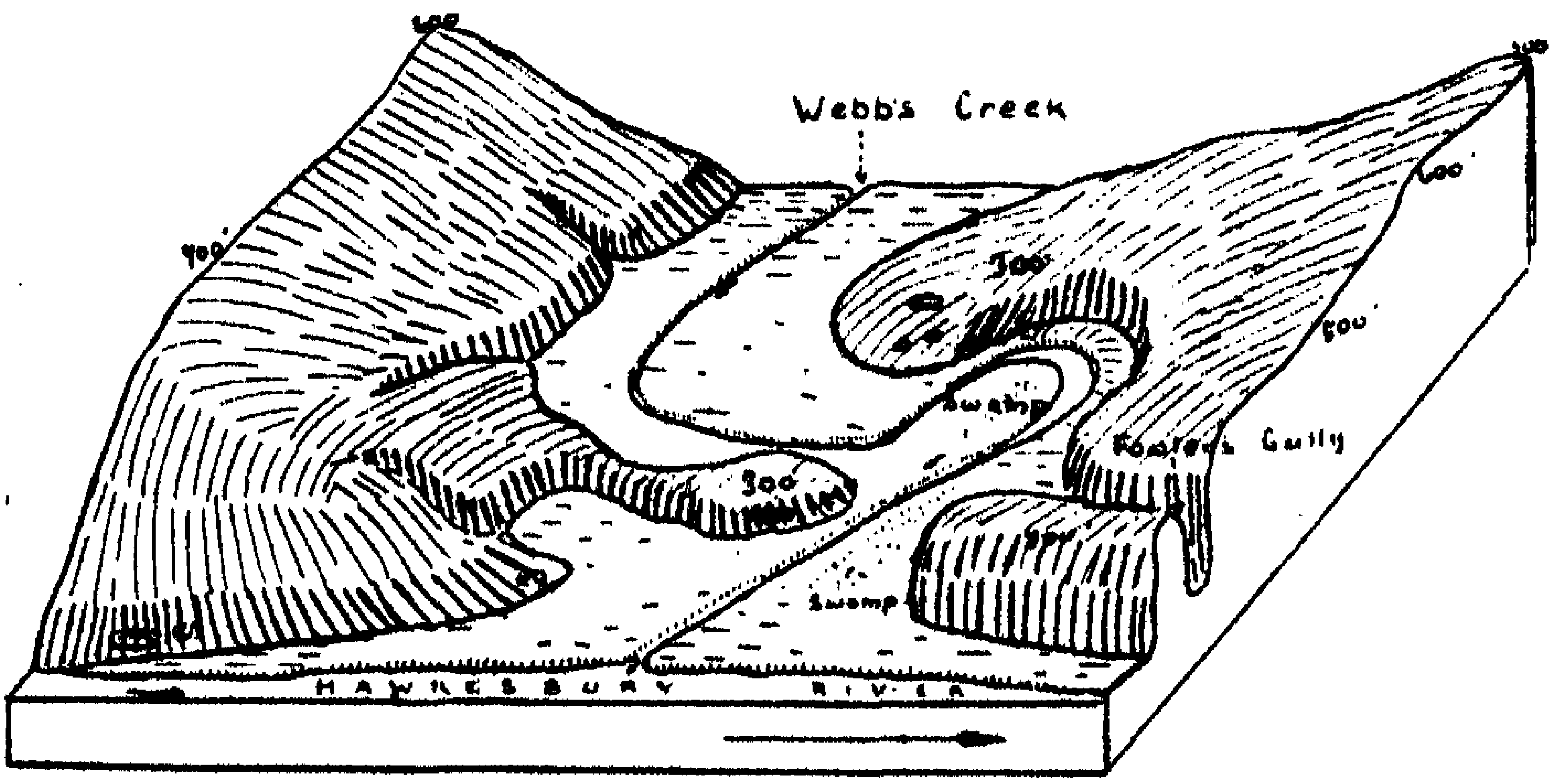


Text-figure 13. Block diagram of Webb's Creek at Cross's farm.

stone knob joined to the main ridge by a long grassy neck, now only 20 feet above the level of the silts (Text-fig. 13). The knoll itself has been considerably eroded, for it is now only 100 feet high, and the presence of a number of boulders at its base indicates that denudation is still active. The present creek swings from side to side in the level silts and on the northern side is close against the sandstone spur. Under normal conditions the creek has not much power of erosion, for it is quite senile, with reeds growing in the sediments along its banks, but with the force of flood waters it is quite conceivable that the creek may some day cut through this neck and, by taking up a new and more direct course, give a condition similar to that at Sackville. Here, however, there has been no tributary gully to assist in the erosion of the neck and the structure more nearly approaches the simple case of a beheaded meander. The flats are used exclusively for agriculture and the homes are built either on the knoll or on the terraces of the main ridge. This ridge has been dissected by juvenile gullies which are now cut off from communication with the stream by the silts. In rainy

weather, therefore, water from these streams spreads out over the flats and the sediment is deposited at the base of the hills in an alluvial fan formation.

At the junction of Webb's Creek with the Hawkesbury River is a low meander spur where erosion has been checked by uplift (Pl. xxxv, fig. 3). The col is still 250 feet above the level of the silts and the knob is 100 feet higher. The surrounding hills rise to 700 feet in places. Over the flat grassy floor of the trough valley the present creek, a mere tidal channel some 20 yards wide, winds its way practically uninfluenced by the original valley in which it has formed a meander within a meander (Text-figure 14).

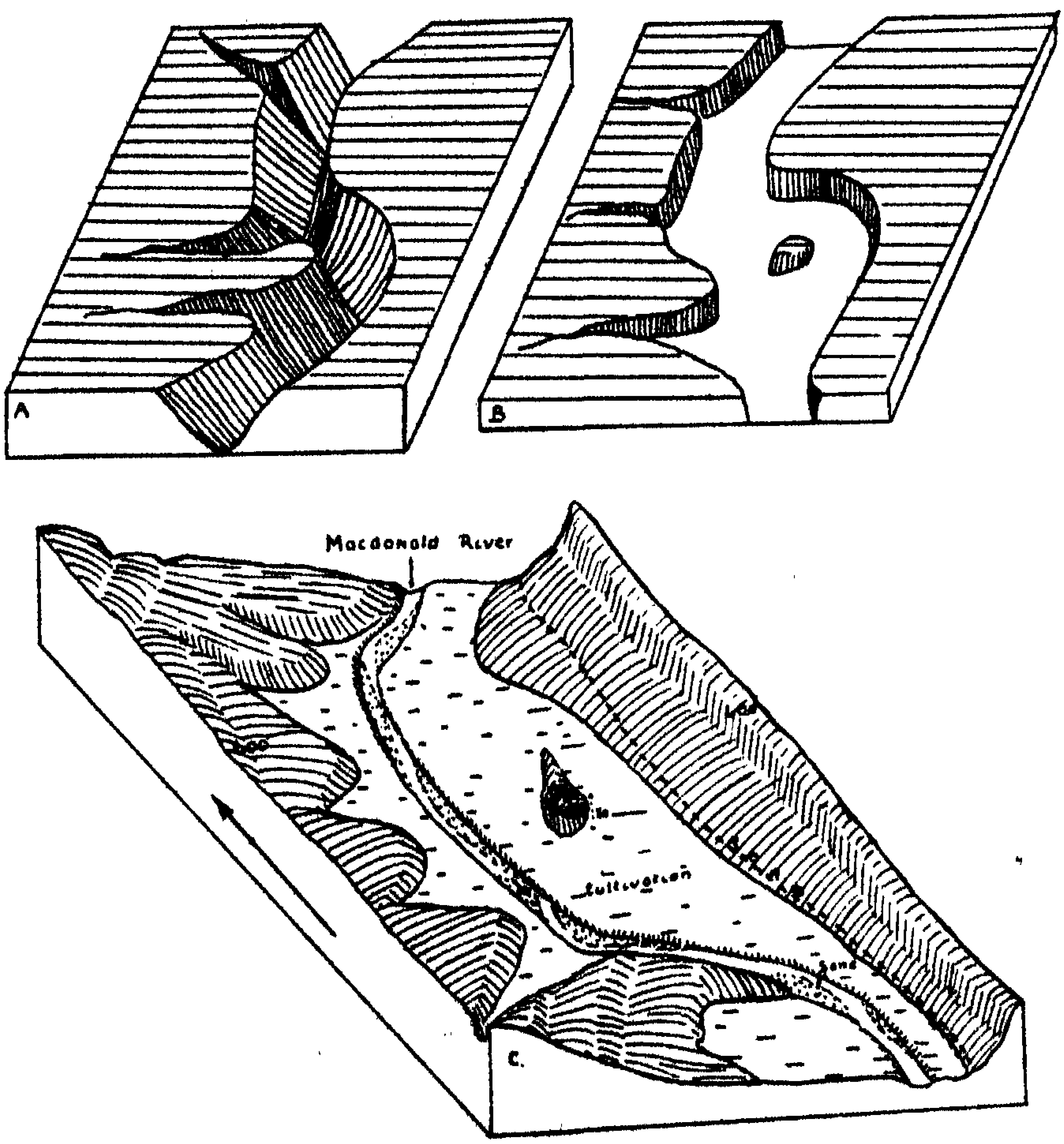


Text-figure 14. Block diagram of Webb's Creek at its junction with the Hawkesbury River.

The creek is not eroding the sandstone hills, for its current has no force except at flood times, when it is strong enough to cause changes in the river course. Patches of *Melaleuca* swamp indicate that such changes have occurred in the past. The development here has been the same as in the preceding cases, but before the neck could be worn down, uplift checked the forces of erosion.

Immediately to the north of the town of St. Alban's on the Macdonald River is another isolated sandstone knoll (Pl. xxxvi, fig. 3). The river sweeps in a wide curve to the west, forming an extensive area of river silts between hills over 600 feet high. The physiography is similar to Sackville, but the knoll, instead of being right at the bank of the river, is farther over to the east and surrounded on all sides with silts. It is only 50 feet high and is covered with houses. The river valley is wide but not deep, and is almost completely filled in with sand. It it obvious, from the nature of the wide valley which separates the knoll from its original spur, that the cutting was done while the river was much larger and before uplift determined the course of the present stream. At the time of rejuvenation the river flowed in a curved gorge with a tributary gully dissecting the spur of the entrenched meander as at Sackville (Text-figure 15, A). The swing of the river was against the northern section of the spur which was thus exposed to erosion on both sides, and the tendency for the tip of the spur to be cut off was developed. Then drowning occurred and during that time the water was able

to wear its way through, leaving the knoll as a small island (Text-figure 15, B). The current then made its way through the passage formed, and the island became smaller and smaller. With the uplift, the river took its present course in a curve through the silts separating the knoll from the spur. The new stream was able to cut out a fairly wide valley, but since then decreasing rainfall has caused a great diminution in the amount of flowing water.



Text-figure 15. A series of block diagrams representing the physiographic development of the sandstone knoll at St. Alban's on the Macdonald River.

Lagoons.—The lagoons in the Hawkesbury district are of various types, but the most common are those similar to the one described as occurring at Pitt Town. In this case the water collects on the flats at the base of the sandstone slope and is cut off from the river by the band of high land which forms the levée. During a wet season flood waters rising over this obstruction and the discharge from small streams on the hills collect in the low area and, having no way of escape, simply lie there to dry up into a swampy area during the summer months. Such

regions are very common and may be seen at Sackville, on the flat point which divides Gloucester from Sussex Reach and in numerous other places of similar physiography.

Longneck Lagoon is another type. It is a low-lying area about half a mile from the river, to which it is joined by a narrow channel. The main northern road is built up across the lagoon at its point of junction with this outlet. The headwaters of the lagoon are eroding shale ridges, but at the top of the flat area they have cut through the shale and the sandstone is exposed. At the time of uplift the river eroded its valley partly in sandstone and partly in shale. Then, with the drowning, the whole valley was inundated, but more silts were deposited at its mouth than farther back in the hills, where the water collected between the sandstone valley walls. Thus, with uplift, the silts developed into an area of undulating land separating the lagoon from the river.

The Wheeny Lagoon is formed in part of the Little Cattai trough, and is simply a small branch of the main valley which has no large headwater streams, and so has not become silted. It has hardly been affected by the recent uplift and is still in a drowned condition. The sediments deposited in the mouth of the Little Cattai Valley have formed a bar which divides the lagoon from the main stream. At some seasons flood water fills the entire valley and the bar is covered.

Another type of lagoon occurs along the river, where recent silts have piled up against the rocky bank and have thus formed a bar cutting off the outlet for a wet weather stream. In this case the water collects in a pool at the base of the hills and is only separated from the river by a bar of silt through which it gradually drains away.

Summary of Physiographic Development.

1. An upland area dissected by a juvenile river with the formation of rounded waterworn pebbles.

2. Peneplanation.—The river reached the senile stage and meandered over a level surface of Wianamatta shale with the pebbles still present in its bed.

3. Uplift.—The more northerly region was warped slowly to form a barrier across the river which, for a time, was able to cut out its valley at an equal pace and so preserved its meandering course. As it penetrated the shale to the sandstone beneath, the shape of the meanders was influenced by the rectangular arrangement of the joint planes.

4. The land in front of the warp subsided slightly, the flow of the water was checked, and a lake formed between the highland of the northern and western warps. In this lake sediments were deposited, until finally the water became high enough for the river to drain away through its previous notch and so continue to cut out its original valley.

5. The main river eroded its valley to the base level of the sea and the lake alluvials were dissected. Numerous new tributaries flowing into the stream attacked the uplifted surface and eroded juvenile gorges.

6. Drowning.—The sea invaded the river valleys as far back as Windsor and flowed up the tributaries where the valleys were at base level. In the deep water channel so formed a large quantity of sediment was deposited.

7. Secondary uplift.—A small oscillation which exposed the silts deposited the base of the tributary gullies and in the main channel against the swing of the current.

8. Recent deposition of silts as flood levées, beaches and spits in the main river, and alluvial fans in the trough valleys.

FLOODS OF THE HAWKESBURY.

The widespread headwaters of the Hawkesbury River make it very liable to flood the low-lying flats of the Richmond-Windsor district. The water is discharged from two main headwater systems through the Warragamba and the Nepean. Conservation dams on the upper Nepean have stored some water for the last 20 years and it is interesting to note that during that time there has been a marked decrease in the size and frequency of the floods experienced at Windsor. However, an investigation, the details of which are to be given in another paper, has shown that dams cannot prevent floods and that those erected on the Nepean have not been the cause of the decrease at Windsor. By holding back water at the time of general discharge they make the rise of the water less abrupt and lessen the height to which it attains, but the value of the dams in actual prevention varies in proportion to the amount of water already stored at the beginning of the flood rains. On the other hand it is quite evident that there has been a steady decrease in precipitation over the Hawkesbury catchment area since 1870, which has lessened the flow of water down that river and has therefore decreased the likelihood of floods.

OCCUPATIONS AND RESOURCES.

The Hawkesbury district is an agricultural and pastoral region which supplies Sydney with quantities of fruit, vegetables, eggs and milk. In this respect its proximity to the metropolis is important, as it is possible for the day's harvest to be sent down overnight and sold in the city the following morning. The first crop to be grown in the Windsor district was wheat for the supply of the young colony, but the soil was found to be too rich, as it made the grain rank and coarse, so maize very quickly took its place. Maize, in its turn, is passing out, for in competition with the wheat from the western districts it sells so cheaply that it hardly pays for production. The chief occupation in the southern area is now the cultivation of market gardens where all varieties of vegetables for the city's consumption are produced. Some farm lands are used for maize, lucerne and other feed crops, which are stored in concrete silos for the cattle during the winter months. North of Wilberforce the river silt areas are used for fruit growing. The main production is that of citrus fruits, oranges and mandarins, but at Leet's Vale and elsewhere are large orchards of stone fruits, peaches, apricots, plums, etc. In many places the stone fruit trees have been replaced by the citrus, since the perishable nature of the former makes their transport a matter of some difficulty. The soil between the trees is used for vegetables, mainly for local consumption, though peas and beans are sent to Sydney during the season. The dairying industry is important at places all along the river, but its centre is along the banks of the Macdonald River where the land is mainly used for pastoral purposes. Most of the farmers also rear pigs which live on the skim milk and excess fruit from the orchards. One of the lesser occupations is the keeping of poultry, and large runs are to be seen on the hills of Wilberforce and McGrath's Hill where the soil is not good enough for agriculture.

The minor industries of the area have not been fully developed. At Sackville, grapes are grown and the entire output from the extensive vineyard is used

in the production of wine and brandy at works in the vicinity. In the town of Windsor, there is a factory where milk is pasteurized before being sent to Sydney, and also a tannery and a cordial factory. The most flourishing works in the district are those of the Riverstone Meat Company from whose large slaughter-house most of the supplies of fresh meat for Sydney are obtained. The fishing industry is of some importance in the Wiseman's Ferry area, where the river is salt. Other factories have been erected in the past, but have failed mainly through lack of local support. One for condensed milk at Windsor and another for butter at the Ferry were forced to close down, while two attempts at saw-milling, one at Wiseman's Ferry and the other at Cattai, were failures.

The industrial development of the Windsor district is definitely limited owing to the absence of a source of power in the near vicinity, but there are also other difficulties impeding the progress of the area which might either be modified or removed. The main one of these is the centralization of the markets at Sydney, where the produce from all parts of the State is collected to be sold cheaply at competitive prices before being distributed through the State, again to be sold at prices twice as high. In the St. Alban's district farmers have ceased to send goods to Sydney but take them instead by lorry to Cessnock; a rising town of mining importance, it offers a good market for just such produce as the farmers have to sell. Another difficulty with the production of foodstuffs is the necessity of quick transport to the city markets. Near Windsor there is the railway, but farther north the produce is collected by cargo boats which either take it to the train at Brooklyn or else steam all the way to Sydney. These boats cannot navigate the river as far as Windsor owing to the ever-increasing sand banks. No action is being taken to oppose the natural forces and keep the channel clear, or to prevent the river from widening its meanders at flood time; a factor which causes much dissatisfaction. The best way of overcoming the difficulty of quick transport would seem to be to do away with its necessity by establishing local markets and factories. There is no reason why condensed milk, butter and cheese should not be manufactured in the Hawkesbury district, and these goods would be much more suitable for transport than either milk or cream. The productivity of the land would also be greatly increased if it were properly manured and irrigated and a succession of crops grown.

The region of Hawkesbury sandstone is at present practically useless, but it also has possibilities of development. Sandstone soil is a light sandy loam with low water capacity, but good capillary power (Jensen, 1914). It is fairly warm and, with proper treatment, well adapted for early crops and fruit growing. "Cultivation and manuring have completely altered both the mechanical and chemical condition of shale and sandstone soils. They have been brought to the condition of good basalt soils and original differences in mechanical and chemical composition have been almost eliminated" (Jensen, 1914). Even in its present condition the sandstone supports a growth of timber sufficiently valuable to make saw-milling a profitable concern if properly undertaken. The following letter from the Forestry Commission of New South Wales makes this clear: "In the gullies along Little Cattai Creek and Kelly's Arm Creek and their tributaries in the parish of Maroota, there is a fairly large quantity of Blue Gum and Turpentine timber of very good quality and eminently suitable for saw-milling and pole purposes. On the ridges adjoining the main road, Windsor to Wiseman's Ferry, there is a large quantity of Ironbark and Stringybark interspersed with Casuarina and other growths. These, while not being suitable for milling purposes,

would make good fuel. The saw-milling and pole timbers are from 15 miles distant from the railway and are difficult of access. It would require machinery to haul this timber out of the steep gullies where it is situated. The quality of a great quantity of the timber growing in the locality is such that its treatment and utilization would be economically possible if the difficulties surrounding its extraction and transport could be overcome, and the present work of reconditioning the main road, which is now proceeding, will in a large measure contribute to overcoming these difficulties".

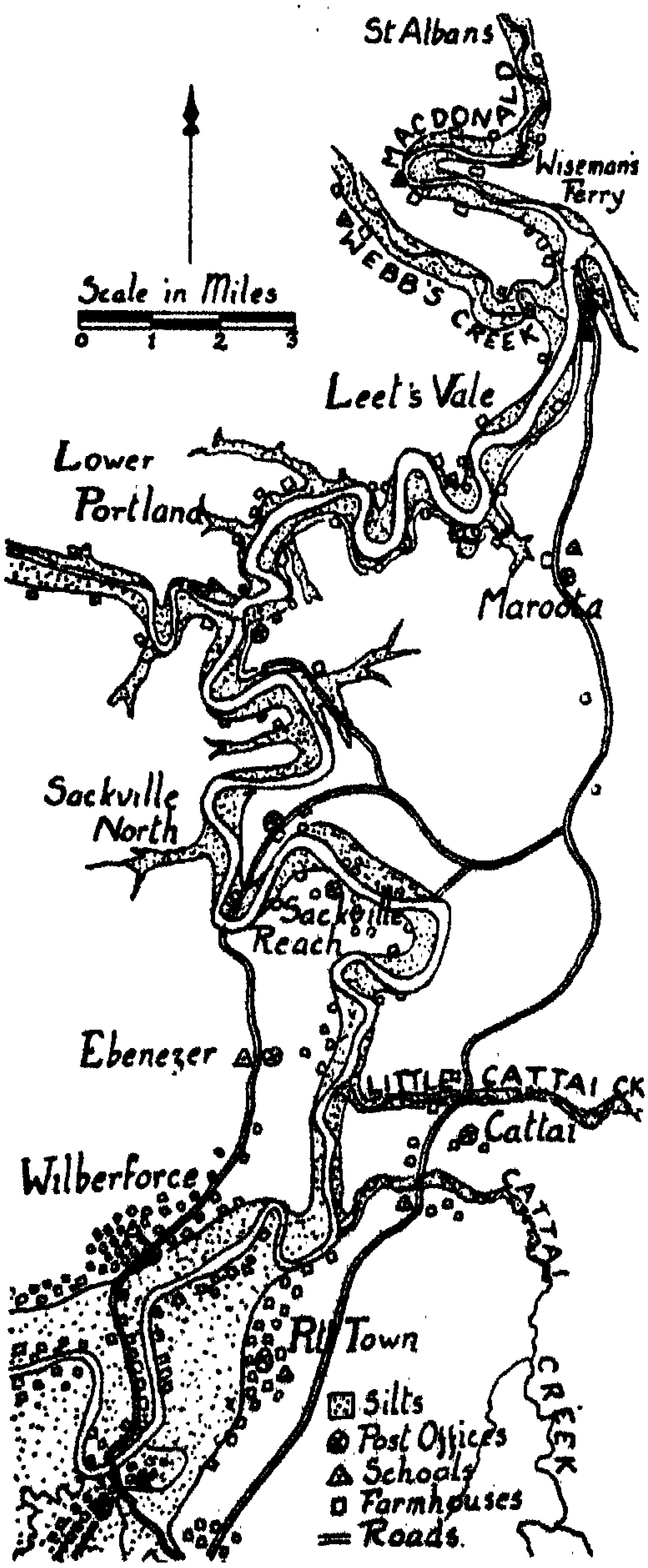
Population and Townships.

That the region was inhabited by large tribes of aborigines before the invasion of the white settlers there is no doubt. Traces of their occupations are still to be found in the rock carvings, cave drawings, tomahawks, grooves, etc., descriptions of which are given elsewhere. The black people themselves have died out and the only representatives of the race are a few half-castes living on the Aboriginal Reserve at Sackville and in a group of huts at Tizzana.

The white population of the Hawkesbury district may be divided into three main groups each of which is dependent on physiographic control (Text-fig. 16). The distribution is variable, the region of greatest density being in the vicinity of Windsor where the first group is to be found. This area constitutes a definite natural region of fertile lowlands which support a dense rural population, centring at the town of Windsor and the two smaller villages of Wilberforce and Pitt Town. It is the only region where the population shows any degree of unity, for it is the only area where the alluvial flats on which the people live are extensive. The second population group consists of the small village clusters which form links in the chain of communication throughout the uplifted district. These clusters occur where the river flats are extensive enough to maintain a few farms as at Sackville and Lower Portland, or at definite positions along the lines of communication, such as Cattai, Maroota, and the small centre at Wiseman's Ferry. The third group is made up of the numerous isolated families which are established along the banks of the river wherever the areas of silt at the base of the sandstone highlands afford land for cultivation. This group is limited to the uplifted region of juvenile dissection and the isolation of the farmers is due to the barren nature of the sandstone.

The population is perhaps increasing slightly in the first group, but elsewhere there is a marked diminution. In the northern districts the fertility of the flats is decreasing owing to deposits of sand, so that, while the older people still make a living from their farms, there is a tendency for the younger generation to go elsewhere. The resulting decrease in population is reflected by the public schools at the various townships. Windsor school has a large number of pupils and at Wilberforce and Pitt Town, the schools, though small, are still of importance. Ebenezer and Sackville North have typical country schools where the pupils are about 30 in number and are taught together by one teacher in a small building which is half residence. At Cattai and Lower Portland conditions are similar and the small schoolhouse has about 25 pupils. To the north of Cattai schools have been built at every small township, but the supply has now exceeded the demand to such an extent that most of them are closed. At Lower Macdonald a school was built in 1871, but has now been closed for the past 15 years. Its place was taken by one at Webb's Creek which was shut down two years ago. Schools at Leet's Vale and Maroota have been closed recently, as the minimum number of

ten pupils could not be guaranteed. There is now no school between Lower Portland and Wiseman's Ferry, yet the latter school has only 30 pupils and it is suggested that the school at Laughtondale should be closed and the pupils brought to the Ferry by launch.



Text-figure 16. Map showing the distribution of population between Windsor and Wiseman's Ferry.

The size and function of the various townships depends on the population group which they represent.

Windsor, the only town of any magnitude within the area, is one of the oldest settlements in New South Wales, for it was officially established by Governor Macquarie in 1810 as a centre for the district of Green Hills which had been settled since 1794. Since the time it was first selected as a safe site for the building of the State granaries, it has always been a depôt where the produce of its agricultural region is collected and despatched to market. It may therefore be classified (Aurousseau, 1921) as a supply town having both functions of collection and distribution. The importance of the town depends on its position in the centre of some good agricultural land on the banks of a fairly large river. These two factors were of far more importance in the early days than they are now, and it has been shown above how its advantageous position gave Windsor a period of greatness in the past which has not been equalled since. With the expansion and growth of settlement the change had to come, for a town which flourished because its rural district was the main source of supply would naturally decline when other agricultural lands were found, farther from the metropolitan area, but brought closer by improved methods of communication.

Windsor of to-day is very different from the city of the past. The old buildings have become dilapidated, for the sandy loam on which the town is built has proved a poor foundation and the bricks made from the local soil were not strong enough to stand the test of time. As a centre of culture and administration it is no longer great, but its surrounding district is still agriculturally rich and the town has simply passed through a period of decline in taking up its correct relative position in the State. According to figures supplied by the Government Statistician for 1923 (Windsor and Richmond Gazette, 1925), Windsor was 25th on the list of principal country towns in New South Wales and had then a population of 4,220 people. In 1921 the population was 3,808 so that during those three years there was an increase of 412. Owing to the arrangement whereby Sydney forms the main industrial centre for the entire State, there are in New South Wales comparatively few large towns. Outside the metropolitan area the only towns of outstanding importance are the mining districts of Newcastle, Broken Hill and Lithgow. Among other and more purely agricultural towns Windsor holds its own and has a larger population than such places as Cootamundra, Young, Singleton, Penrith and Kempsey.

Being spread out along a fairly narrow peninsula, the town has a definitely linear arrangement, and the main street from the railway station to a point above the Windsor Bridge is one mile long. The northern end of the town is highest and has nearly all the historic buildings, such as the courthouse and the military barracks. The industrial area is to the south in proximity to the railway line, which has been built here because the country is more level. The water supply is pumped up from the river, while electric light and power are obtained from the works at the Hawkesbury Agricultural College one and a half miles away. The minor industries carried on in the town are very few and have been mentioned before. The future development of Windsor will depend on the progression or otherwise of its rural district and the growth of local industries. The work of making the town attractive to visitors needs the efforts of a progress committee, which, if combined with Government assistance in fascining the river to keep an open channel, would be well repaid by increased activity in a place which has become almost stagnant. "Windsor does not move back or go ahead. It simply moves on the even tenor of its way growing its crops and looking

askance at strangers. Windsor is settled in its place, it gathers its harvest and sends it to market, it works quietly and earnestly and sleeps well . . . . . especially sleeps." (Windsor and Richmond Gazette, 1920.)

Wilberforce and Pitt Town are similar both in origin and present day function. They were established at the same time as Windsor as places of refuge from flood, and consist of a cluster of houses owned by the settlers whose farms are in the danger zone. They have the usual store, butchery, school, churches, police station and town hall and are fairly important since their rural district is fertile enough to support a large number of people. Yet they are both dwarfed by their proximity to Windsor, which is in the same natural region and has the advantage of the railway. Wilberforce is the larger township of the two since its rural district is the larger and its proximity to the river makes it of some slight importance as a health resort.

Ebenezer, Cattai and Maroota are small village clusters whose existence is due to their function as links in the chain of communication between Windsor and Wiseman's Ferry. They are all situated in the barren sandstone uplands surrounded by a small and scattered population of people who make a precarious living from orcharding citrus and passion fruit. The village clusters are scattered and their centre is marked by the post and telegraph office, which, at Cattai and Maroota, is also the general store. An important feature of the two first townships is the school, but since the one at Maroota was forced to close down, this centre is limited to a general store and post office and a small hall for public meetings and recreation. Cattai has also a town hall which is built in proximity to the general store with the school half a mile away. Ebenezer represents the settlement at Portland Head, and has the famous Ebenezer chapel which, with the school and post office, makes up the entire township.

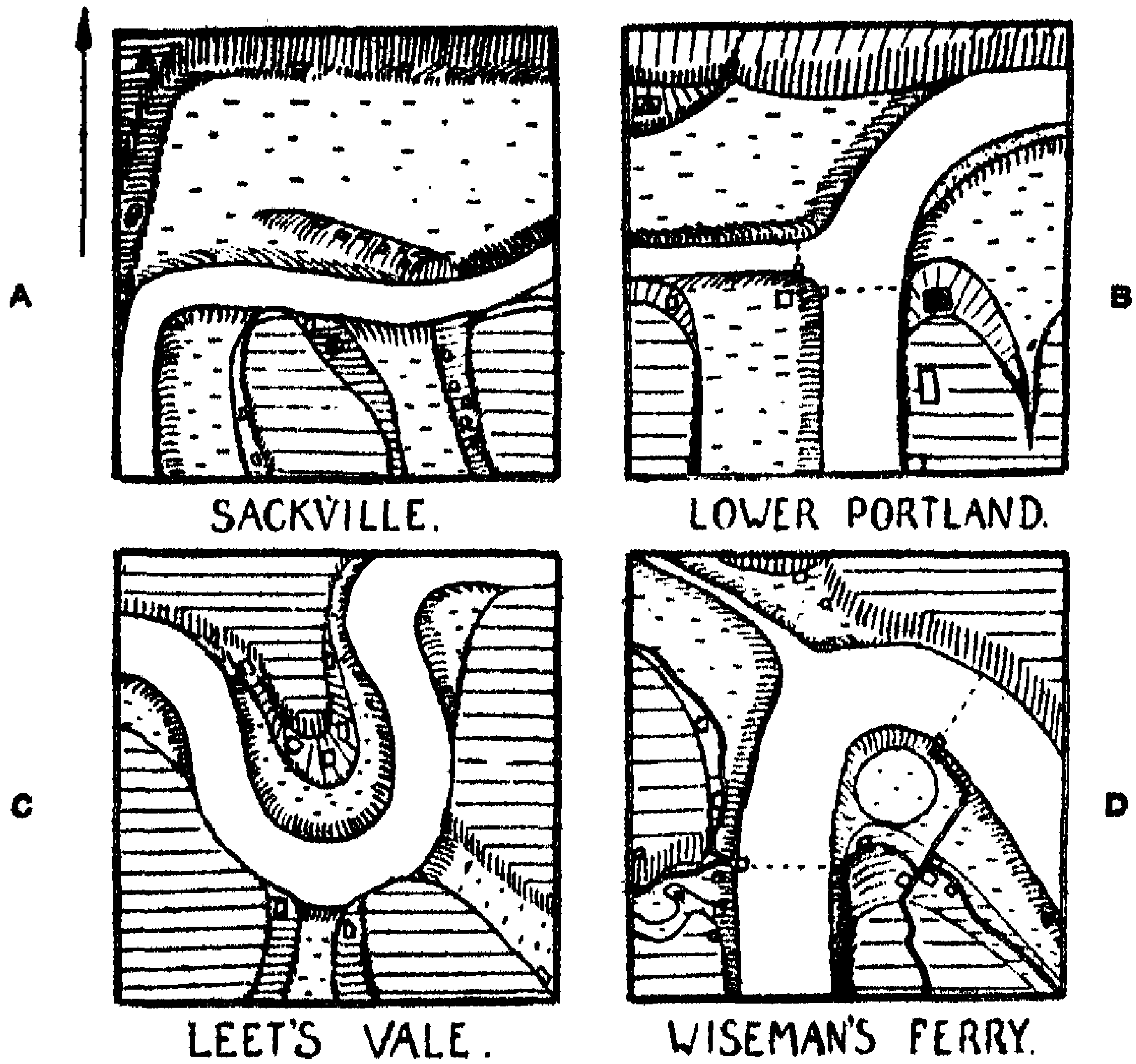
Sackville and Lower Portland are clusters which have been formed where the river flats are sufficiently extensive to support a small number of farms. They are not on the direct line of communication, but are situated on the river bank so that their medium of collection and distribution is the cargo boat. Each has its post office, which, by circulating mails and newspapers, keeps the isolated district in touch with the outside world. Sackville Reach Post Office is built on a spur opposite the lowlands of "Mud Island" which supports a fair community of farmers, who row across daily for their mail (Text-figure 17, A). In this locality Dr. Fiaschi's vineyard provides occupation for a small Italian community of its own. Sackville North is a small centre on the top of the ridge with a post office, general store and recreation grounds with tennis courts, which serve all the farmers both in this region and from other more northerly districts. The Sackville School is also built on the side of the ridge.

Where the Colo joins the Hawkesbury is an area of flat land and the region is known as Lower Portland. It contains within its postal area 24 families, who gain their living chiefly from agriculture and stock raising. Its only public buildings are the post office, school and recreation hall (Text-figure 17, B), but a small store has been erected and may one day assume the function which is now carried out by the trading boat. The school is built on the banks of the Colo.

Leet's Vale is a district of isolated farm houses between Lower Portland and Wiseman's Ferry. The township consists of a residence which is part post and telegraph office; a school on the other side of the river, now closed owing to lack of pupils; a small church and about half a dozen farms in the near vicinity (Text-figure 17, C). The distance between Lower Portland Post Office and

Leet's Vale Post Office is 8 miles and the mailman on this road serves 17 farm-houses on each side of the river, an average of about one house every half-mile. As the people do not often write letters the main traffic is in newspapers and is just sufficient to justify the existence of the post office.

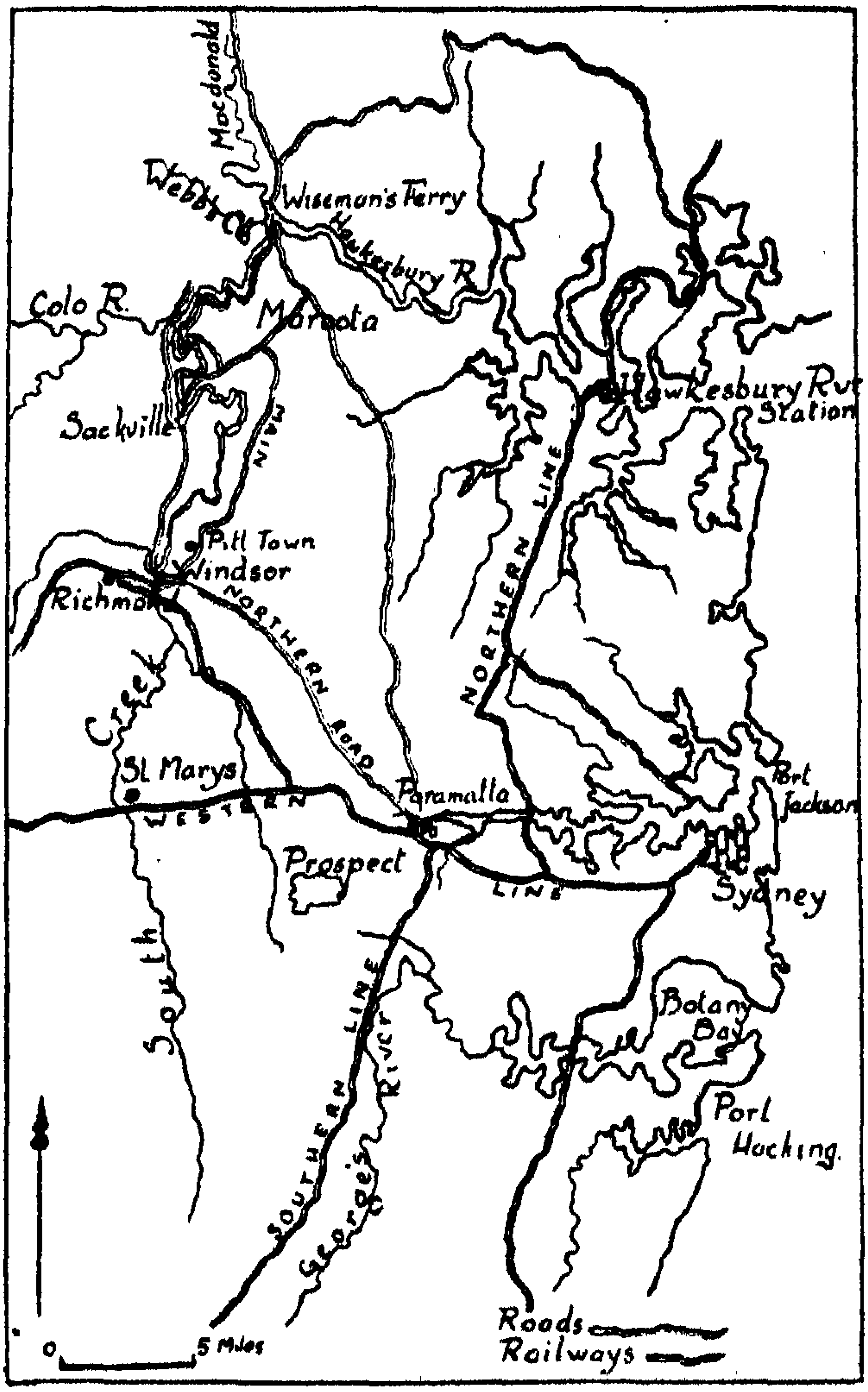
Wiseman's Ferry.—The small township at the ferry is important mainly because of its position, where the main northern route crosses the Hawkesbury River (Text-figure 1). It is here that the river turns to the east and the township is built on the flats at the foot of the spur on the inside of the bend. On the



Text-figure 17. Sketch maps of four townships between Windsor and Wiseman's Ferry.
A. Sackville. B. Lower Portland. C. Leet's Vale. D. Wiseman's Ferry.

opposite side the river is joined by the Macdonald and Webb's Creek and the silts at the mouth of these streams, as well as those of the main river to the east of the ferry, form a rural district dependent on the township for supplies. A large travelling population is catered for by the hotel and a modern garage, while the needs of the farmers are met by the post office, store, church, school and police station (Text-figure 17, D). It is not important as a depôt for the produce of its rural district since the river here forms a wide, deep channel for the cargo steamers which trade to and from Sydney. These boats are quite competent to carry out the function of supply to the rural population within the area, so that, when the main northern highway is changed, as suggested, to the old Peat's Ferry road, the Wiseman's township will practically cease to exist, except as a

tourist resort. The grandeur of the sandstone hills with the ribbon of water and areas of green flatland at their base, together with the available pleasures of swimming, boating and fishing will always make this district attractive to visitors.



Text-figure 18. Sketch of the Sydney district showing the relationship of Windsor to the Metropolitan area.

COMMUNICATIONS.

1. *Railways.*—A branch line leaves the main western railway at Blacktown and travels north through Riverstone and Windsor to the terminus at Richmond (Text-figure 18). Farm produce from the western side of the Hawkesbury is brought by lorries to Windsor, whence it is taken by train to Sydney. For the eastern side of the river Mulgrave is the nearer station. The main northern

line from Sydney passes through Hawkesbury River Station and some of the farm produce of the area is brought here by the cargo boats and is loaded on to the trains. Between the Windsor-Richmond line and the main northern line there are no other railways to serve the area and communication is carried on either by road or by water.

2. *The river* forms a direct line of communication for boats between Sydney, Wiseman's Ferry and the districts as far south as Sackville. Above this town silts have blocked the river and, as shipment is one of the easiest and least expensive methods of sending goods to Sydney, it has been suggested that the stream should be controlled by fascines and breakwaters which would make it sluice away its own silt. To the north of Sackville the river is by far the most important means of communication and it serves as a link between the isolated farms which have collected on the flats along its banks, while the road, by taking a more direct route across the ridges, passes through comparatively barren country and so benefits fewer people. Two companies run cargo boats along the river and the service is very good. The boats call at individual wharves to unload orders or to collect produce and they also take passengers to and from places along the river. There are no stores between Sackville and Wiseman's Ferry and their place is taken by the tradesmen's launches. Special boats run twice a week with meat and bread and there is also a general trading boat built exactly like a shop which can supply every necessity. There are two of these specially designed floating stores, and they have their headquarters at Wiseman's Ferry. One boat trades up the Macdonald river and down towards the mouth of the Hawkesbury as far as Mangrove, while the other travels up the river to Sackville and includes the Colo as far as the tide will permit.

Roads.—The main northern road is built through this area from McGrath's Hill, one mile east of Windsor, over fairly even country to Cattai and then on to the ferry along the ridges which are left as divides between gullies of juvenile dissection. There is another route through Windsor, Wilberforce and Sackville which joins the main road north of Cattai and this is frequently used, although the punt across the river at Sackville is a slow and tedious link and one that fails altogether at flood times. To the north of Sackville a branch from the main road is built down the western side of the ridge to the river, which it then follows closely all along its meandering course and in and around the numerous trough valleys until it also arrives at Wiseman's Ferry. This road is only made important as a link in the chain of communication by its use by the mail coaches, but it is attractive to visiting cars since the beauty of the scenery it reveals is indescribable.

A daily service 'bus is run between Windsor and Wiseman's Ferry to connect at the latter place with a launch which travels between the ferry and Hawkesbury River Station, thus enabling visitors to make the round trip in the course of a single day. Other 'buses are run between Windsor and Sackville, but for intercommunication between the various small townships along the river the best method is by the mail service. A mail car travels daily between Windsor, Pitt Town, Cattai and Maroota. The mail coach from Windsor to Sackville meets another coach which takes the letters to Sackville North and Lower Portland. From Lower Portland to Leet's Vale the mailman travels on horseback and visitors use the cargo boats for this stage of the journey. The same transport may be taken between Leet's Vale and the ferry, but it is also possible to travel between these two places in the mailman's sulky.

The river itself acts as a barrier to overland communication since it is everywhere too wide and deep to be crossed except by boat. Besides the bridge at Windsor there are five punts on the main river; two in the vicinity of Wiseman's, two at the mouth of the Colo and one at Sackville. Of these the first two are the most important. The river is 370 yards wide where it is crossed by the Wiseman's punt, which is at present an all important link between the south and the north. The Webb's Creek crossing is about three-quarters of a mile south of Wiseman's and is constructed to take the heavier traffic. It links up with the road along the Macdonald to St. Alban's and onwards to Wollombi and other important centres. About five miles from its mouth the Macdonald is crossed by another ferry, but it is very small and often out of order owing to the constant deposition of sand banks. At St. Alban's the river is crossed by a good bridge and since it is here almost dry it would seem that the bridge would have been of much more use if erected at the location of Book's Ferry. The punt at Sackville has a span of 230 yards to cross. It is in constant requisition, since it links one of the main routes to Wiseman's Ferry from Windsor. At the junction of the Colo with the Hawkesbury River there is one punt across the main stream and one across the tributary, but these are not so frequently employed and have but one operator. The punts are small wooden structures which will not usually hold more than two vehicles at a time. They are manipulated by a paid operator who lives close by on the bank and is required to put travellers across the river at any time. The service is maintained by the Government as part of the system of communication.

Summary and Conclusions.

The region described is one of simple geological and ecological factors complicated by physiographic development, which has produced structures of the utmost importance in the distribution and occupation of the settlers.

The drowning and uplift which have given its present topography to Broken Bay, also influenced the Hawkesbury River as far south as Windsor.

The hinge line of the uplift which produced the northern warp passes through Wilberforce and Pitt Town and thus divides the district between Windsor and Wiseman's Ferry into definite physiographic regions.

The effect of the uplift was to expose the barren sandstone to the north and, by blocking the course of the river for a period, to cause the formation of the "fossil lake" area to the south.

Further erosion, followed by drowning and the secondary uplift, caused the beheading of entrenched meanders and produced the important silted valleys of trough formation.

The period of maximum importance for this area was in the early days, when the colony was small enough and the silt lands were fertile enough to supply the settlers with sufficient food. The farmers of those days gradually occupied every area of fertile land afforded by the river flats and trough valleys, which make oases of fertility between barren upland ridges.

The sandstone barriers have prevented expansion, so the limits of settlement attained during the first 30 years of its foundation have prevailed ever since.

The present population is still to be found only on the silts, and is therefore dense to the south on the flats of the old lake, and scattered in small clusters along the river flats on the north.

Unfavourable marketing conditions, combined with decreased fertility of the soil, are causing a decrease in the population, except at Windsor which is practically stationary.

The region has no coal or oil to supply a source of power and its economic development is therefore definitely limited.

Future development is only possible along lines of intensive cultivation and the expansion of minor industries.

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EXPLANATION OF PLATES XXXV-XXXVI.

Plate xxxv.

1. The famous Presbyterian Chapel at Ebenezer.
2. View of the Douglass Farmland at Leet's Vale showing its typical "trough valley" formation.
3. View of Webb's Creek at its junction with the Hawkesbury River.

Plate xxxvi.

1. The Township of Wiseman's Ferry, looking south.
2. The incised meander of the Hawkesbury River at Leet's Vale.
3. An isolated sandstone knoll surrounded by farmland, in the vicinity of St. Alban's on the Macdonald River.
4. View of the Macdonald River to the north of St. Alban's.

NOTES ON AUSTRALIAN MARINE ALGAE.

iii. THE AUSTRALIAN SPECIES OF THE GENUS NITOPHYLLUM.

By A. H. S. LUCAS, M.A., B.Sc.

(Plates xxxvii-xlv.)

[Read 24th November, 1926.]

The genus *Nitophyllum* is large, well-defined and world-spread; most abundant in temperate seas but occurring also in the tropics. De Toni (*Sylloge*, 1900) lists 68 classified species, 9 others less known and not found in fruit, and 4 more which, in the opinion of J. G. Agardh and himself, ought very probably to be included in the genus. A further species was described in 1913. This gives the considerable total of 82 forms which have been thought worthy of specific rank. Of these 24 are Australian, two of which, however, described by Zanardini, need further investigation, in the opinion of De Toni.

The Characters of the Genus.

The fronds are flat, expanded in one plane, now narrow almost linear dichotomous or pinnate, more usually broader cuneate-flabelliform or even reniform palmatisect, occasionally pinnatisect with an elongated principal segment, sessile or more usually stipitate.

The fronds are thinly or more firmly membranaceous, consisting of a single stratum (monostromatic) or of two or more strata (di- or pleio-stromatic) of rounded or angular cells, filled with colouring matter, usually rose-coloured but sometimes of a duller red or purple, the surface cells, when larger, giving to the frond, as seen from the surface by aid of the microscope, a beautifully areolated appearance. The membrane constitutes the whole frond in the simpler species and in the juvenile stage of others, but is stiffened in some by veins, strings of rather elongated cells, which combined in the stipes may form a midrib, and then separate and branch in the lamina. In this case intermediate layers of cells are formed. In the subgenus *Polyneura* the veins are conspicuous, joined in nerves which radiate from the bundle in the stipes and are produced more or less into the frond.

The fruit consists of cystocarps and sori of tetrasporangia, borne on separate individuals. The cystocarps are sessile on the frond, depressed, with a wide basal placenta emitting threads which bear clavate-ovate carpospores within a radiate cellular pericarp, through an opening in which (carpostomium) the spores escape. Nothing seems to be known of the antheridia. The tetrasporangia are rounded, "triangularly", or more strictly tetrahedrally, divided into four spores, and occur in definite groups (sori), which may be scattered over the surface or be local in their distribution.

SUBGENERA.

J. G. Agardh divided the genus into four subgenera, basing his classification mainly on the development of the veins.

LEPTOSTROMA.—Frond all membranaceous, very thin, monostromatic, without trace of veins or nerves.

A Mediterranean group with one species occurring on the shores of Britain and France.

AGLAOPHYLLUM.—Frond di- or pleio-stromatic, without trace of veins or nerves.

Of the 21 species, 11 are confined to Australia including Tasmania, viz., *N. pulchellum*, *N. crispum*, *N. sinuosum*, *N. gunnianum*, *N. cartilagineum*, *N. proliferum*, *N. monanthos*, *N. endivaefolium*, *N. fallax*, *N. erosum*, *N. pristoideum*.

POLYNEURA.—Frond di- or pleio-stromatic, with conspicuous veins often combining into nerves prominent in the fronds.

Of the 14 species listed by De Toni there is only one Australian representative, *N. gattyanum*. To this subgenus, however, we may have to add the little known *N. hymenema* of Zanardini.

CRYPTONEURA.—Frond di- or pleio-stromatic, with inconspicuous veins, discoverable under the microscope, but not combining into prominent nerves.

Of the 27 species listed by De Toni, there are 10 Australian forms, viz., *N. uncinatum*, *N. ciliolatum*, *N. minus*, *N. affine*, *N. multipartitum*, *N. parvifolium*, *N. caulescens*, *N. polyanthum*, *N. validum*, *N. curdieanum*.

Possibly here should be placed the imperfectly known *N. obsoletum* of Zanardini.

The veins would appear to be special differentiations which serve (1) as channels of intercommunication between the cells, (2) as supports to strengthen the lamina. The plant is more highly differentiated in proportion to the development of this venous system. From this point of view—of greater differentiation—it would seem more natural to arrange the subgenera as follows:

(1) *Leptostroma*. Monostromatic, veinless.

(2) *Aglaophyllum*. Di-pleio-stromatic, veinless.

(3) *Cryptoneura*. Di-pleio-stromatic, veins present, inconspicuous.

(4) *Polyneura*. Di-pleio-stromatic, veins well developed, conspicuous.

By this arrangement we pass naturally into the neighbouring genera, with fruits similar to those of *Nitophyllum* but possessing a well marked midrib. In *Hemineura* this midrib is not continuous, but isolated in the main frond and also in the individual lobes. In *Hypoglossum* the midrib is continuous. So that we have a natural gradation from veinless to midribbed forms.

It should be noted that in many species sori appear first only in the outer segments, but in more adult plants are formed also in areas extending more or less over the disk.

Species.

AGLAOPHYLLUM.

Section 1. *Membranaceae* J. Ag.—Species with the whole frond very delicate, gelatino-membranaceous, the sori definite, rounded, scattered without conspicuous order over the frond.

The three species quite entire on the margin.

1. NITOPHYLLUM PULCHELLUM Harv. Pl. xxxvii, figs. 1, 2.

Trans. Roy. Irish Acad., vol. 22, 1854, p. 549.

Frond subsessile, thinly membranaceous, veinless, dichotomous-fastigiate, segments linear or cuneate, margin undulate-crisped, approximate over patent sinuses. Sori rounded, ocellate, scattered over the median surface. Colour a delicate rose.

Harvey did not describe the cystocarps. In Wilson's specimen (see below) they are numerous, but not crowded, scattered over most of the frond (Plate xxxvii, fig. 1).

One of the smaller species. The Harveyan plant in the Sydney Herbarium has a spread of 7 cm. (Pl. xxxvii, fig. 2). Wilson's plant is rather larger. That in the Melbourne Herbarium is from King George's Sound. Harvey obtained his plants in W.A. J. Bracebridge Wilson presented a specimen gathered in Western Port to the Melbourne Herbarium.

2. NITOPHYLLUM CRISPUM (Kuetzing) J. Ag. Pl. xxxvii, fig. 3; xxxviii, fig. 1.

Kuetzing Sp., 1849, p. 868, Tab. Phyc. xvi, t. 39.

Frond shortly stipitate, thinly membranaceous, veinless, oblongate, the margins densely undulate, notably produced into oblong laciniae. Cystocarps prominent, chiefly on the laciniae. Sori small, 1 mm. diam., numerous, rounded or oblong, scattered over the whole surface of the upper part of the frond. Colour a beautiful rose-pink sometimes with a purple shade.

Length to 22·5 cm.

A species distributed on both sides of Bass Straits, especially abundant in the estuary of the Tamar.

Tasmanian specimens forwarded early to Harvey were by him considered as identical with the Atlantic and Mediterranean *N. punctatum* (Stackh.) Greville. In *Nereis Australis* (1847) he says: "The Tasmanian specimens are very similar to some British individuals of this very variable species" (p. 119). Kuetzing in 1849 distinguished the Tasmanian form as a distinct species *Aglaophyllum crispum*, and was followed by Agardh. The latter says: "In colour and tenuity it agrees extremely well with the European species but differs in the stipes, the thickened part sometimes continued, in the norm of ramification sufficiently constant in the southern species and in the sori being much smaller, at first punctiform, at length ocellate" (Epicrisis, p. 448). Our species certainly has a facies of its own, and differs by its definite laciniae and very small sori from any examples of *N. punctatum* which I have seen.

3. NITOPHYLLUM SINUOSUM Lucas.

PROC. LINN. SOC. N.S.W., xxxviii, 1913, p. 55, Pl. ii and iii.

Frond shortly stipitate, thinly membranaceous, veinless, oval or reniform in circumscription, broadly expanded, densely lobed and undulate; stipes cuneate, to 6 or 7 mm. long, soon evanescent above; margin of the lamina quite entire, running out into short sublinear lobes with obtuse almost truncate apices, but rarely into laciniae. Cystocarps rounded, 1 mm. diam., numerous in the medial region of the adult frond, each surrounded by a concentric paler zone. Sori oblong, the longer axis in the direction of growth, 2 mm. long, scattered all over the upper part of the frond. Colour a beautiful rose-carmine, changing when wet to orange on exposure to the air, the rose colour returning on drying. (Conf. *N. versicolor* Harv. of the British flora.)

Dimensions of frond exceedingly variable in fruiting plants, up to 35 cm. × 20 cm.

Apparently an Eastern species; only met with so far on the coast of New South Wales. It is common in Botany Bay and I have it also from Port Jackson and Port Stephens. It grows on *Zostera* and *Cymodocea*.

Harvey's *N. stipitatum*, *Phyc. Austr.*, No. 393, is transferred to the genus *Platyclinia*.

We have no species of Agardh's Sections ii and iii recorded from Australia.

Section iv. *Incrassatae* J. Ag.—Species with the adult frond palmate-lobed or dichotomous-pinnatifid, thickened, subcarnose, composed of numerous superposed series of cells, the sori minute, rounded, scattered irregularly over the outer parts of the frond.

(1) Frond dilated, the margin armed with small teeth bent alternately upwards and downwards, visible under the lens.

4. NITOPHYLLUM GUNNIANUM Harv.

London Journal of Botany, vi, 1847, p. 403.

Figured by Harvey in *Nereis Australis*, Pl. 47, and better in *Phyc. Austral.*, Pl. 224.

Frond with a short stipes, to 8 mm. long, broadly membranaceous, flabellate, profoundly subpalmato-laciniate, the laciniae cuneate-oblong, broad, the margins minutely toothed or crenulate, entirely veinless and the lower part often perforated by foramina; the strata of cells more numerous in the stipes and basal parts, the cells of the outermost stratum similar to those of the intermediate layers. Cystocarps rather scant, about 1 mm. diam., scattered over the surface of the frond. Sori very minute, punctiform, less than 3 mm. in diam., very numerous and closely packed together, occupying the upper and outer regions of the frond. Colour a dull purple, dusky when dry.

Dimensions to 25 × 30 cm.

Tasmania, north and east; Flinders, Port Phillip Heads.

J. Bracebridge Wilson, in his catalogue of Algae collected at or near Port Phillip Heads and Western Port, published in the *Proceedings of the Royal Society of Victoria*, Vol. iv, Part ii, 1892, includes two forms which Agardh, to whom Wilson submitted his plants, distinguished as species, *N. obscurum* described in the *Epicrisis* in 1876 and *N. subfulvum* "Ms. spec. nov. in 1889".

N. obscurum is altogether omitted from De Toni's *Sylloge*, though apparently Agardh had not withdrawn his species in 1892. Indeed De Toni (*Syll.*, iv, p. 980) goes so far as to suggest that *Nitophyllum obscurum* J. Ag. is perhaps only *Pollexfenia lobata* (Lamour.) Falk. The fruits and structure are so extremely different that Agardh and Wilson could hardly have confused the plants. I give a translation of Agardh's description and comments. His material came from Tasmania.

NITOPHYLLUM OBSCURUM J. Ag.

Epicrisis, 1876, p. 452.

"Frond with cuneate stipes, the nerve beyond the stipes soon evanescent, broken up into obsolete approximated veins occupying the lamina medially below, frond sordidly purple, cuneate-flabellate, subpalmatifid, segments subpinnately

lobed, rounded at the apex; sori minute, punctiform, scattered over the whole surface.

"The habit almost of *N. gunnianum*, but, inspected more carefully, it appears to be a sufficiently distinct species. The stipes is more evident and costate, the costa soon evanescent above the stipes in the inferior medial thickened part of the frond, which appears most finely striated, the striae radiating fanwise from the obsolete veins. The surface cells in this medial part are longer and united in diverging lines; the outer part of the lamina areolated with shorter angulate cells. Further the lamina is more subdivided in rounded lobes, wider above, and, as far as I could see, not perforated by pores. The sori which I saw altogether punctiform though truly in my specimen still quite juvenile".

The plants of *N. gunnianum* which I have gathered or seen vary exceedingly in the depth to which they are dissected and in the thickness and extent of the stipes. The cause of perforations which are met with so frequently in *N. gunnianum* and *N. affine* is not known. Harvey was in doubt whether they were "caused by marine worms or by natural and unequal decay". They are very unequal in size, rounded or oval or almost linear in shape, and quite casually distributed over broader areas of the lamina, sometimes abundant, sometimes almost or quite wanting. Their presence or absence does not appear to me to be a character of specific importance. I do not know upon what grounds De Toni rejected *N. obscurum*, but I am altogether inclined to follow him.

Wilson records *N. subfulvum* as a manuscript species only. There are four of Wilson's specimens with this label in the Melb. Herb., two sterile, one with cystocarps and one with sori. They seemed to me to be only a paler form of *N. gunnianum*.

To sum up, *N. gunnianum* is a "good" dominant species, and a large series of specimens furnishes forms intermediate between and connecting its numerous varieties.

(2) Frond dichotomous or subpalmatifid, the margin quite entire.

5. NITOPHYLLUM CARTILAGINEUM Harv. Plate xxxviii, fig. 2.

Trans. R. Irish Acad., xxii, 1854, p. 549.

Frond sessile, veinless, thick, carnose, subdichotomous-compound, the laciniae linear, subdivaricate, spreading over wide sinuses, undulate-crisped, with very obtuse apices. Cystocarps apparently not seen. Sori, not minute, elongate, scattered over the segments. Colour a dark dull red.

Dimensions moderate, with a spread of 10 cm. in my larger plant.

A Western Australian species gathered by Clifton and Harvey near Fremantle. In the Melb. Herb. there is a single specimen of Harvey's with well-developed sori. There is a similar specimen in the Sydney Herbarium (Pl. xxxviii, fig. 2). I have two specimens from Rottnest I. in the same vicinity gathered by Mr. A. Cayzer while in the Biological Department of the University, Perth. They are unfortunately sterile.

Section v. *Proliferae* J. Ag.—Species with the lamina of the frond lancoid, with lobes prolificating from the margin, at length forming a subpinnatifid frond, in the younger stages membranaceous, in the adult carnose, the whole constituted of similar layers of cells, gradually forming a thickened lower costal region, sori linear, occupying a narrow linear area within the margin of the frond.

6. NITOPHYLLUM PROLIFERUM J. Ag. Plates xxxviii, figs. 3, 4; xxxix, fig. 1.

Analecta Algologica, ii, 1894, p. 63.

Junior frond simple lanceolate on a short stipes, the adult at length apparently pinnate owing to the outgrowth from the margin of phylla, at first obovate, then lanceolate, each with a narrow stipel below and thickened below in the middle of the frond so as to appear costate. Cystocarps immersed within the margin. Sori at length occupying an elongated area within and parallel to the margin. Colour purplish.

The mature phylla 3 to 4·5 cm. long, 4 to 7·5 mm. broad.

Port Phillip Heads and Western Port, dredged by J. Bracebridge Wilson. A species well marked by the arrangement of the sori.

Section vi. *Monantheae* J. Ag.—Species with a decompound lobed frond, the upper lobes rounded-obtuse membranaceous, the lower with a gradually thickened costal region forming below a more or less conspicuous stipes, the subterminal lobes dilated, at length generating a solitary sorus surrounded by a sterile border.

7. NITOPHYLLUM MONANTHOS J. Ag. Plate xxxix, fig. 2.

Sp. ii, 1863, p. 655.

Frond subsessile, thickened below, adhering to other algae by radicles springing from the under surface, at first entirely decumbent, the more adult plant ascending upwards, pinnate-dichotomous with sparing dichotomies, segments linear, 3-4 mm. wide, margins sinuate-crenate, the surface obsoletely veined, the veins distinguishable only under a strong lens, the surface cells all similar subhexagonal. Cystocarps not seen; the terminal segments bearing the sori palmate-lobed dilated above a narrower isthmus; sorus sub-solitary oblong sinuous, occupying a transverse disk. Colour rose.

Frond 4 or 5 cm. long. One of the smaller species, epiphytic on other algae.

In the Melb. Herb. are specimens from King George's Sound (Daemel), Encounter Bay, Port Fairy and Wilson's Promontory. Thus the plant ranges over the whole of the south coast of Australia.

A species connecting the sections Aglaophyllum and Cryptoneura, perhaps more naturally included in Cryptoneura. In his *Epicrisis*, Agardh placed it near to *N. uncinatum* and *N. ciliolatum*.

8. NITOPHYLLUM ENDIVAEFOLIUM (Hook. et Harv.) J. Ag. Plate xxxix, fig. 3.

Delesseria endivaefolia Harv., *Fl. Tasm.*, Algae, 1860, p. 6.—Agardh removed it to *Nitophyllum* in his *Epicrisis*, 1876.

Frond narrow, thickened below, caulescent, dichotomous, undulate, laciniae growing out pinnately from the margin, the segments linear, the inferior ones thickened medially so as to form prominent costae, the superior ones most densely undulate-crispate, almost everywhere curling over the principal caulescent segments; the cells forming the costa twice as long as broad, the cells of the surface over the costa a little longer than the cells of the margin. Cystocarps minute punctiform scattered on the upper laciniae, about one to each. Sori occurring on the outermost minute lobes of the laciniae and correspondingly minute, surrounded by a sterile border; sometimes in a trilobed lobe there is but one central sorus. Colour reddish-purple.

Dimensions, 15-20 cm. long. Mean diameter of laciniae 1 mm.

Coast of Victoria—Hopkins R., Barwon Hds., Port Phillip Hds., Western Port.

The elongation of the costal cells indicates a tendency to form a venous system.

Section vii. *Costatae* J. Ag.—Species with the frond apparently dichotomous and flabellately expanded, the segments linear, sterile and younger flat, membranaceous, growing out into an obtuse apex, the inferior gradually thickened forming a midrib margined by a narrow wing, the fertile generating semilunar sori within the lobules of a subundulate margin.

9. NITOPHYLLUM FALLAX J. Ag. Pl. xl, fig. 1.

Sp. iii, 3, 1898, p. 48.

Frond narrowly linear, decompound-dichotomous, flabellately expanded, with a thickened costal region at length transmuted into a flattened midrib, margins practically entire, the median laciniae linear, the uppermost a little wider, rather obtuse, the sterile flat, the fertile subundulate at the margin, at length producing semilunar sori. The superficial cells over the midrib similar to those of the margin; a transverse section shows a front constructed of many series of superposed cells. Cystocarps not seen. Sori semilunar in the outer lobules. Colour dull dark red.

Dimensions: 10-15 cm. long; segments 3·4·5 mm. wide.

Only known from examples gathered by Wilson. In the Melb. Herb. there are three specimens, all collected by him at Port Phillip Heads, and, unfortunately, all sterile.

Section viii. *Armatae* J. Ag.—Species with frond apparently pinnately decompound, younger segments linear or oblong, flat, armed with a dentate serrulate or fimbriated margin, the lower in the adult with a thickened costal region forming a more or less apparent thickened midrib, the fertile segments generating numerous sori within the margin.

10. NITOPHYLLUM EROSUM Harv.

Phyc. Austral., No. 392, 1859, Pl. 94.

Frond attached by a discoid radical callus, a short thickened cartilaginous stipes produced above into a soon vanishing midrib, and a lamina cuneate below, then dichotomo-subpinnatifid, segments broadly linear, patent, irregularly forked, with dense minute fimbriations on the margin, fimbriae subulate, finally divaricate-multifid; the frond is composed of 3 or 4 series of cells, and the surface is loosely areolate. Cystocarps 1 mm. diam., sparse, scattered irregularly, hemispherical, usually crowned by a ring of forked appendages like marginal fimbriae. Sori oblong or linear, minute, scattered over the whole surface. Colour a deep rose.

Dimensions moderate, 2-10 cm. long, segments 8-12 mm. wide.

Specimens in the Melb. Herb. from Champion and McDonnell Bays, Port Fairy, Port Phillip Heads and Western Port. Harvey and Clifton gathered the plant near Fremantle. Specimens were sent me from Houtman's Abrolhos, collected by the Percy Sladen Expedition. Thus the range is extensive.

Between *N. erosum* and *N. pristoideum* in De Toni's *Sylloge*, occurs a species *N. serrulatum* J. Ag. (Sp. iii, 3, 1898, p. 51). The habitat is given "ad insulam cygnorum, anglice 'Swan Island' dictam (Dna. Baudinet)". I do not know whether this is an Australian locality or not. No sori were seen. The habit is stated as recalling that of *N. pristoideum* but the ramification is more complex. Later and fuller information may make the geographical and systematic position clearer.

11. Nitophyllum pristoideum Harv.

Phyc. Austral., No. 399, 1862, Pl. 229.

Frond with a discoid radical callus and an elongated stipes 2-4 mm. wide, thickened below, decompound-caulescent, dichotomous-subpinnate with linear segments, the lower thickened medially, the upper flabelliform-fastigiate crenulate at the margin with minute rather acute teeth; a delicate vein-system extends far into the segments; the inner cells in several superposed series. Cystocarps hemispherical, scattered over the disk, mostly towards the apices of the segments. Sori minute, oval, aggregated in terminal sublinear segments. Colour dark red, turning to brown on drying. Substance membranaceous, rather rigid.

Fronds 10-20 cm. long.

In the Melb. Herb. are specimens from Lacepede and Encounter Bays, South Australia, from Port Fairy, Port Phillip Hds. and Western Port, Victoria, and from Tasmania.

Subgenus Polyneura.

12. Nitophyllum gattyanum J. Ag. Plates xl, fig. 2; xli, figs. 1-3.

Epicrisis, 1876, p. 454.

Frond with a subterete stipes, 6-15 mm. long, attached to stones or shells by a number of spreading coloured rhizoids (holdfasts), the stipes passing into numerous diverging stout dichotomously branching and anastomosing costae which gradually subside in the upper regions of the lamina, the lamina cuneate at the base, broadly expanded, oblong in general outline, simple sublobate with an ample undulate-plicate margin. Cystocarps to 1 mm. diam. are situated over the veins, scattered over the upper and outer regions of the frond, the young ones appearing near the margin. The sori occur in the intervenous spaces in the upper and outer regions, rounded, smaller than the cystocarps. Colour a beautiful rose-carmine.

Fronds to 24 cm. long, typically 5 or 6 cm. wide, but sometimes expanded laterally to a much greater breadth. Occasionally 2 to 4 plants grow gregariously.

Very abundant in September and October in the estuary of the Derwent R., Tasmania, and Agardh's specimens were sent by Mr. Gatty from this locality. In the Derwent the plants bearing cystocarps are much more frequent than those bearing sori. J. Bracebridge Wilson gathered the species at Port Phillip Heads and Western Port.

Harvey clearly possessed plants of this species from the Derwent and from Southport, Tas., but he included them under the name *N. multinerve* with forms found at Cape Horn and in New Zealand. J. Agardh distinguished the Tasmanian forms as a separate species under the name of *N. gattyanum*.

Nitophyllum hymenema Zanardini. Plate xli, fig. 4.

Phyc. Australicae Novae, 1874, p. 497.

I quote the description given by De Toni (*Syll. Florid.*, p. 664): Fronde vix stipitata, tenuissima, elato-laciniata, margine undulato-crispata, multivenosa, venis inferioribus robustis, flexuoso-ramosis, superne evanescentibus; cystocarpiis crassiusculis, prominentibus, in parte superiore frondis creberrime sparsis.

Hab. ad "Hobartown" Tasmaniae (Zanardini).

Agardh and De Toni list it as a species to be inquired into. There are no examples in the Australian Herbaria.

Among the very numerous examples I secured of *N. gattyanum* there is a group of three fronds with many prolonged laciniae. One of the fronds is

apparently exstipitate, but the other two possessed short stipites. My group bore sori. The colour and structure are quite those of *N. gattyanum.* These were the only laciniate plants I saw. I am inclined to think that Zanardini must have received this form, and described it as a separate species two years before *N. gattyanum* was described by Agardh. It is singular that he received only the aberrant apparently very rare form and not the typical one which is common in this locality. However, nothing can be settled without examination of Zanardini's material, if it is still preserved.

Subgenus Cryptoneura.

Section i. *Acrosoria* J. Ag.—Frond without nerves, but furnished with superficial veins sub-singly running through the frond, with small-celled intervenous spaces, the sori solitary on a dilated subterminal lobe, the sterile margin of the frond surrounding the stout rounded sorus.

(*a*) Fronds elongate, narrow, dichotomous or subpinnate, growing up amongst other algae and clinging to them here and there by a lobe transformed into a cirrhus, other lobes often lateral and dilated, generating a solitary sorus within the margin.

13. Nitophyllum uncinatum (Turn.) J. Ag. 1863. Plate xiii, figs. 1, 2.

Fucus laceratus var. *uncinatus* Turner, *Hist.*, 1808, Pl. 68, fig. *c*, *d*.

Frond caespitose, subsessile, narrow, vaguely dichotomous, very decompound, segments linear, acuminate, the upper often secund, curved toward the outer side of the parent segment, and here and there transformed into hamuli for attachment to other fronds or other algae, the lamina with delicate veins. Cystocarps do not appear to have been noted in the plants of any region. Sori: Fruiting segments mostly lateral, shorter, oblong, often trifoliate, the phylla more obtuse, each with a solitary sorus below the apex. Colour rose-carmine.

Dimensions: Atlantic forms, 2-5 cm. long. Australian forms, to 15 cm. long. In both the segments from 2 to 4·5 mm. wide.

Port Phillip, Botany Bay, Port Jackson, Moreton Bay.

Recorded by De Toni from the Atlantic and Mediterranean and from the Cape of Good Hope, but not from Australia. Harvey distributed Australian specimens under the name *N. uncinatum*, and Agardh (*Epicrisis*, p. 466) gives as the habitat of that species "in Mediterraneo et Atlantico calidiore; specimina e N. Hollandia et N. Zealandia vix specie diversa videntur". Our plants, too, are extremely shy of fruiting. Though I have examined hundreds of specimens, I have never found cystocarps, and only once discovered sori, and then only on one segment of a fairly large plant. They were typical of the species.

In 1906 I forwarded specimens from Botany Bay to the British Museum of Natural History, and they were identified as "*N. ciliolatum* Harv. Two fine specimens" by A. and E. S. Gepp (*Journal of Botany*, Vol. 44, August, 1906, p. 258). But our Eastern forms are not ciliate, which is the characteristic feature of Harvey's species, in his description and in the Western Australian specimens we possess of it in the Australian Herbaria.

Our plants are certainly, especially those from Botany Bay, more luxuriant than the Atlantic forms. In the same way our New South Wales plants of *Grateloupia filicina* are four or five times the size of the British plants.

14. Nitophyllum ciliolatum Harv. Plate xiii, fig. 3.

Trans. R. Irish Acad., xxii, 1854, p. 549.

Frond subsessile, vaguely dichotomous, the segments linear, acuminate, here and there curved into hooks, thinly membranaceous, the whole surface finely veined, with minute ciliiform processes arising sparingly from margin and disk. Cystocarps and sori unknown.

Western Australia.—The two examples in the Melb. Herb. are from King George's Sound. They are slenderer and paler than *N. uncinatum* and are typically ciliolate.

N. obsoletum Zan. (*Phyc. Austral. nov.* 1874, p. 498) seems to me to be very likely merely a fragment of *N. uncinatum*. The description given by De Toni is—Fronde sessili (?), tenue membranacea, obsolete venulosa, decomposite pinnato-laciniata, segmentis ultimis pinnato-lobulatis, lobulis obtusis, extremitatibus hic illic hamato-recurvatis.

Hab. ad Georgetown Tasmaniae (Dna. Goodwin).

Frons spithamea (parte inferiore non visa). Fructus ignoti, ex quo species inter eas denuo inquirendas enumeranda.

(*b*) Frond almost freely expanded, not clinging to other algae by hooks, more or less dilated above the middle, bearing above lobes more or less palmately decompound, ultimate lobes rounded obtuse, at length generating a solitary rounded sorus in the disk.

15. Nitophyllum minus (Sond.) Harv. Plate xlii, figs. 4, 5.

Cryptopleura minor Sond., *Alg. Preiss.*, p. 47.

Frond substipitate, very thin above, di-tri-chotomous decompound, segments cuneate or more often linear, traversed by very fine longitudinal sub-branching veins, the inferior subundulate on the margin, the terminal subdivaricate obtuse. Cystocarps not known to the authors of the species. Sori orbicular, subsolitary within the apices of the segments, containing numerous spherical tetrasporangia. Colour rosy. Dimensions small, 2-4 cm. long. Segments 1 mm. wide, but in the plants in the Melb. Herb. to 3 mm.

Under this name in the Melb. Herb. are plants from W.A. (Preiss), Fremantle (Harvey, *Alg. Austr. Sicc.*, No. 296*a*), McDonnell Bay (Mrs. Wehl), Guichen Bay (Dutton) with *sori scattered over the terminal and subterminal segments*, and Port Phillip Heads (Wilson). In the McDonnell Bay plants there are large isolated cystocarps, not confined to the ultimate segments but occurring on the main frond as well.

The species evidently needs further study.

The remaining "species" of the genus are very puzzling to anyone working on the algae of our southern coasts. Those included by Agardh in his section *Periotkia* are all from Victoria and Tasmania, those in his section *Dawsonia* from the coasts of South Australia in addition. Harvey, who studied them first, for some years divided those he met with or which were sent to him, into two species, *N. affine* 1844 and *N. multipartitum* 1847. *N. affine* he looked upon as an extremely variable form, and it was not until 1862 that he divided it into two, marking off the firmer caulescent varieties as a separate species, *N. curdieanum*. He died alas prematurely in 1866. Agardh in 1876 (*Epicrisis*) retained *N. affine* with 5 defined varieties, and separated an allied form as a fresh species *N. parvifolium*, and at the same time described a form allied more closely to *N. curdieanum* as a separate species *N. polyanthum*. Finally, from material dredged by Bracebridge Wilson, he described in 1898 two new species, *N. caulescens* nearer to

N. affine, and *N. validum* nearer to *N. curdieanum*. *N. multipartitum* is easily recognizable but the six other species are evidently very closely related and all sorts of intermediate forms appear. Agardh was a past master in eliciting order out of chaos, as is well seen in his magnificent monograph on the genus *Sargassum*. His four species may well serve as rallying posts about which the varying individuals may be collected, but the classification of the group can only be completely satisfactory after very full series of plants have been gathered and critically compared. As Sir Joseph Hooker remarked to Harvey, "many specimens always break down characters". And again, "we shall never know what are species in some genera and what are not".

Section ii. *Perioikia* J. Ag.—Frond nerveless but furnished with sub-single superficial veins, the intervenous areas composed of small cells. Sori few and scattered without order in the penultimate lobes, rounded, now close together, now rather distant.

(*a*) Frond more delicate almost all membranaceous.

16. Nitophyllum affine Harvey. Plate xliii, figs. 1, 2.

Hooker's London Journal, iii, 1844, p. 447.

Frond stipitate, dilated below, as broad as long, at length perforate between the but little prominent veins and lacerated, the lower segments subcaulescent with a winged border, the upper pinnatifid with teeth or lobes, dilated fanwise, above thinly membranaceous, finely veined nearly to the apices. Cystocarps not described by Harvey. Sori numerous, rather large, subocellate, evolved in upper pinnate-lobed segments. Colour sordidly purpurascent. Dimensions 10-15 cm. long, but sometimes quite small.

Agardh distinguished five forms of this very variable species:

(1) *integriuscula*, frond broadly dilated below, margins lobate-subpinnatifid, apices rounded.

(2) *incisa*, frond deeply incised into cuneate segments, pinnatifid above.

(3) *elongata*, frond divided almost completely into laciniae, wider below, linear, toothed at the margin, the upper a little dilated, rounded at the apices.

(4) *cribrosa*, the whole frond dissected into a multitude of irregular laciniae riddled with holes and themselves laciniated, the upper often narrow linear.

(5) *truncata*, frond below nearly entire, laciniated above, the laciniae broadly linear subtruncate rounded.

Victoria and Tasmania, especially Port Phillip, Port Phillip Heads and Western Port.

17. Nitophyllum multipartitum Hooker and Harvey. Plate xliv, figs. 1, 2.

London Journal of Botany, vi, 1847, p. 404.

Frond stipitate (better seen in young individuals), very narrow, thickened below and becoming caulescent, decompound dichotomous-pinnate, the whole upper part ending in long linear very narrow laciniae, the segments cuneate below, patent, and veined almost to the obtuse apices; the margins entire or often crenulate with minute obtuse processes, more conspicuous in the upper part of the segments. Cystocarps not seen. Sori rather large, numerous, subocellate, in the terminal segments. Colour dark reddish-purple. Dimensions to 10 cm. long. The linear segments 1 or 2 mm. wide, in the cuneate base 3 or 4 mm.

Victoria, Port Phillip and Sealer's Cove, and Tasmania.

There was much confusion over this species among the early investigators and Agardh, as late as 1876, speaks of it as "nec hodie forsan dubiis liberata". He regarded it as approaching *N. minus* and *N. affine*. Superficially it bears resemblance to *N. uncinatum*, but the caulescent habit, very narrow segments, much stouter veins, the sori several in each lacinia and the colour separate it widely from that species.

18. Nitophyllum parvifolium J. Ag. Plate xliv, fig. 3.

Epicrisis, 1876, p. 457.

Frond caulescent below with a thickened subsquamous caulis, narrow, extremely decompound above the ribbed cauline branches, subcorymbose, the segments minute linear subdivaricate quite entire on the margins, the veins extending high up the frond, the ultimate segments crowded rosulate. Cystocarps not seen. Sori rather large subocellate scattered in the terminal segments. Colour not stated. Dimensions not indicated.

The original specimens were sent to Agardh by F. von Mueller from Port Phillip.

In the Melb. Herb. is a soriferous plant under this name collected by Bracebridge Wilson at Port Phillip Hds. I do not know if it was submitted to Agardh. It seemed to me like a smaller narrow *N. curdieanum*. The species was placed by Agardh between *N. multipartitum* and *N. curdieanum*. It certainly requires more investigation.

(*b*) Frond with a gradually thickened costal region, in the upper part of the frond simulating a true midrib.

19. Nitophyllum caulescens J. Ag.

Sp. iii, 3, 1898, p. 70.

Frond stipitate, with a sufficiently conspicuous stipes, at length stoutly costate, vanishing upwards, above expanded into a lamina supra-decompound-pinnatifid, the principal laciniae expanded subflabellately over a cuneately dilated base, the inferior lobes of the laciniae resembling obtuse teeth, the upper elongate growing out into new similar laciniae. The costal region is formed of 5-7 layers of superposed cells, the upper lamina is monostromatic. Agardh does not describe the vein system. Cystocarps subsingle in the upper lobes. Sori few, scattered in the upper lobes of the laciniae. Colour and dimensions unrecorded.

One of the forms sent to Agardh by Wilson. There are two doubtful specimens in the Melb. Herb. collected by Wilson at Port Phillip Heads. Plants I gathered at Flinders seem to me to square fairly well with the above description. These are carmine-purple in colour, and 8-10 cm. long, and both cystocarpiferous and soriferous plants were present.

Section iii. *Dawsonia*.—Frond nerveless, but the whole traversed by veins, running out subsingly and fanwise in the upper frond, in the mid frond united somewhat in bundles, sometimes at the base of the frond supported on a quasi proper costa. Sori minute, rounded, very numerous, formed in series radiating to the margins.

Supradecompositae J. Ag.—Frond at length supra decompound by repeated divisions, forming as it were a true caulis, flattened and either nude or subsquamous with prolifications, the lower laciniae of each rachis shorter.

(*a*) Laciniae pinnatisect, separate almost to the linear rachis, at length soriferous.

20. NITOPHYLLUM POLYANTHUM J. Ag. Plate xlv, fig. 1.

Epicrisis, 1876, p. 461.

Frond with thickened subconvolute squamous caulis, caulescent below, decompound dichotomous-pinnate, segments linear, the lower medially thickened, margin entire or subcrenulate, the upper with veins reaching almost to the rounded obtuse apices. Cystocarps not seen. Sori minute punctiform, very numerous in the terminal laciniae.

Adelaide and Encounter Bay, South Australia, Port Phillip and Port Phillip Heads, Victoria, and Tasmania.

Agardh notes that this species may be distinguished from *N. curdieanum* by the much smaller punctiform sori and by the firmer consistency of the frond so that it is much less frequently perforated by foramina. The sori are more numerous and crowded than in any other of the species.

(*b*) Laciniae palmatifid, expanded fanwise above a more or less distinct stipes.

21. NITOPHYLLUM VALIDUM J. Ag.

Sp. iii, 3, 1898, p. 78.

Young frond almost altogether membranaceous, more or less decomposed in laciniae subpalmately expanded, gradually forming a proper caulis, thickened below, flattened above, generating from the upper branches or from a proliferous margin, decompound dichotomous laciniae spreading fanwise, the whole frond penetrated by veins. Cystocarps not seen. Sori minute, rounded, forming in the terminal lobes several series, radiating fanwise between the veins towards the margins. Dimensions to 30 cm. long. Single laciniae 6-10 mm. wide.

South Australia (Miss Hussey), Victoria (J. Br. Wilson). There are no examples in the Melbourne Herbarium. I have not seen it.

The ramification is said to be nearly that of *N. curdieanum* but *N. validum* has the terminal segments more than twice as broad. In any case it appears to be very like *N. curdieanum*, and may be only a luxuriant form of that species.

22. NITOPHYLLUM CURDIEANUM Harv. Plate xlv, fig. 2.

Phyc. Austral., 1862, Pl. 151 (partim).

Frond with discoid attachment, caespitose, below narrow and caulescent, with caulis 3-9 mm. wide, stoutly costate, subalate, subconvolute, squamous, alternately or dichotomously branching or proliferating, lamina composed of 4 or 5 strata of cells, subflabellately decompound, rather pinnatifid than dichotomous, the segments linear or cuneate, flat or undulating, the lower medially thickened, entire or subcrenulate at the margin, the upper subflabellately pinnatifid penetrated by veins almost to the extremities of the rounded obtuse apices. Cystocarps scattered in the principal segments. Sori numerous, rather large, subocellate, evolved in the upper pinnati-lobed segments. Colour brownish-red, darker on drying. Dimensions: 15-30 cm. long, ultimate laciniae to 4 mm. wide.

Apparently not found in Western Australia, but gathered from Lacepede, Rivoli, Encounter, Macdonnell and Guichen Bays in South Australia, Port Fairy, Warrnambool, Port Phillip and Western Port in Victoria and in Tasmania (Melb. Herbarium). My specimens are from Warrnambool, Barwon Heads and Point Lonsdale.

EXPLANATION OF PLATES XXXVII–XLV.

Plate xxxvii.

1. *Nitophyllum pulchellum*. Port Phillip Heads (Wilson). With cystocarps.
2. *Nitophyllum pulchellum*. Fremantle (Harvey). With sori.
3. *Nitophyllum crispum*. Tasmania. With sori.

Plate xxxviii.

1. *Nitophyllum crispum*. Tasmania. With cystocarps.
2. *Nitophyllum cartilagineum*. Fremantle (Harvey). With sori.
3. *Nitophyllum proliferum*. Segment enlarged.
4. *Nitophyllum proliferum*. Sorus enlarged.

Plate xxxix.

1. *Nitophyllum proliferum*. Western Port (Wilson). With sori.
2. *Nitophyllum monanthos* Harvey. Sterile.
3. *Nitophyllum endivaefolium*. Barwon Heads (Lucas).

Plate xl.

1. *Nitophyllum fallax*. Port Phillip Heads (Wilson). Sterile.
2. *Nitophyllum gattyanum*. Hobart (Lucas). With cystocarps.

Plate xli.

1. *Nitophyllum gattyanum*. Hobart (Lucas). Sterile, showing nerves.
2. *Nitophyllum gattyanum*. Holdfast.
3. *Nitophyllum gattyanum*. Hobart (Lucas). With sori.
4. *Nitophyllum hymenema* ? Hobart (Lucas).

Plate xlii.

1. *Nitophyllum uncinatum*. Botany Bay (Lucas). Sterile.
2. *Nitophyllum uncinatum*. Segment with sori.
3. *Nitophyllum ciliolatum*. (Harvey). Sterile.
4. *Nitophyllum minus*. Gulchen Bay (Dutton). With sori.
5. *Nitophyllum minus*. McDonnell Bay (Wehl). With cystocarps.

Plate xliii.

1. *Nitophyllum affine* var. *lobatum*. Port Phillip Heads (Harvey).
2. *Nitophyllum affine*. Tasmania.

Plate xliv.

1. *Nitophyllum multipartitum*. Georgetown (Harvey).
2. *Nitophyllum multipartitum*. Tasmania.
3. *Nitophyllum parvifolium*? Point Lonsdale (Lucas).

Plate xlv.

1. *Nitophyllum polyanthum*. Port Phillip Heads (Wilson). With sori.
2. *Nitophyllum curdieanum* (Harvey). With sori.

ON SOME LAND PLANARIANS FROM BARRINGTON TOPS, N.S.W., WITH DESCRIPTIONS OF NEW SPECIES.

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(With 5 Text-figures.)

[Read 27th October, 1926.]

The Land Planarians described in this paper were collected at Barrington Tops at the southern end of the Mount Royal Range, about 160 miles north of Sydney, by the Sydney University Party led by Professor Harrison in January and February, 1925.

The collection comprises six species, representing the three genera *Geoplana*, *Artioposthia* and *Platydemus*. Four species proved to be new. Types of these will be deposited in the Australian Museum.

Generic Synopsis of Australian Species.

In his "Monographie der Turbellarien. II. *Tricladida terricola*", L. von Graff has outlined a classification for all Land Planarians. As this work is not easily available, a synopsis of the families and genera known to occur in Australia is given here.

Family *Geoplanidae*.

With numerous retort-shaped eyes at the anterior end and on the sides of the body, or eyeless. Border of anterior end of body provided with little pits with sensory edges. Tentacles, suckers and headplate absent.

Genus *Geoplana* Fr. Muller (1887).

Geoplanidae with broad creeping sole. Anterior end provided with a glandular margin. Mouth and genital aperture on the ventral surface. Copulatory organs without muscular gland organs. Gland cushion absent.

Type species, *Geoplana rufiventris* Fr. Muller.

Genus *Artioposthia* von Graff (1899).

Geoplanidae with elongate body and broad creeping sole. Anterior end provided with glandular margin. Mouth and genital aperture on ventral surface. Copulatory organs provided with muscular gland organs. Gland cushion absent.

Type species, *Artioposthia fletcheri* Dendy (1891).

Family *Rhynchodemidae*.

With two eyes borne on the anterior end of the body. Tentacles, suckers and headplate absent.

Genus *Rhynchodemus* Leidy (1857).

Rhynchodemidae with a long drawn out body, oval in cross-section, with a much reduced narrow creeping sole and bearing sensory edges at the anterior end. Eyes small.

Type species, *Rhynchodemus terrestris* Fr. Muller.

Genus *Platydemus* von Graff (1896).

Rhynchodemidae with massive plano-convex body with broad creeping sole with glandular and sensory edges. Large retina eyes.

Type species, *Platydemus thwaitsei* Moseley (1875).

Family *Bipalidae*. (Extra-Australian).

Body elongate with the anterior end spread out to form a headplate. Margin of this headplate beset with small pits with sensory edges, and above with numerous eyes. Creeping sole small, beginning at the base of the headplate.

Genus *Placocephalus* von Graff (1896).

Bipalidae with headplate developed, plate with a semi-circular outline.

Type species, *Placocephalus fuscatus* Stimpson (1858).

(*Placocephalus kewensis* has been introduced into Australia.)

Family Geoplanidae.

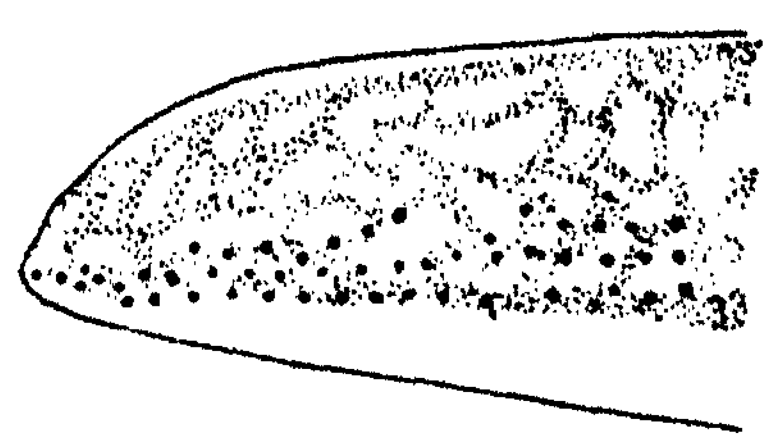
GEOPLANA CAERULEA Moseley. Text-fig. 1.

Coenoplana caerulea Moseley, *Q.J.M.S.*, xvii, N.S., 1877, p. 285.—*Geoplana caerulea* Fletcher and Hamilton, PROC. LINN. SOC. N.S.W. (2) ii, 1887, p. 361, Pl. v.

The colour of the dorsal surface varies from royal-blue to prussian-blue with a median dorsal whitish stripe not clearly defined. The ventral surface is much lighter in colour. There is an indication of a median ventral white stripe fading out behind the genital aperture. The anterior end is reddish-orange in colour. The eyes are situated at the anterior end extending into the blue portion of the body (Text-fig. 1).

The specimens collected vary in length from 3 cm. to 7 cm. (spirit specimens). In a specimen 5·2 cm. in length the mouth is 2·3 cm. and the genital aperture 2·8 cm. from the anterior end.

This was the commonest species collected, being found on rocks near the Barrington River, on damp moss, on the trunks of trees and under rotten logs. It is unlike the common *Geoplana caerulea* collected near Sydney, which has a more yellowish median dorsal stripe. This variety corresponds more closely with the type described by Moseley (1877, p. 285), "Entire body of a dark prussian blue colour, somewhat lighter on the under surface of the body with a single mesial dorsal longitudinal stripe of white. Length 5 cm., extreme breadth 4 mm. Mouth central, generative aperture 8 mm. posterior to the mouth. Parramatta, near Sydney. Under the bark of a species of Eucalyptus". There must be added to this description an observation made by von Graff (1899, p. 341). He examined



1. 2.

Text-fig. 1. Side view of anterior end of *Geoplana caerulea*.
Text-fig. 2. Side view of *Geoplana citrina*.

Moseley's type in the British Museum and points out that the anterior tip is coloured orange-yellow in that specimen. From these observations it may be concluded that *Geoplana caerulea* var. *typica* is a blue planarian with a mesial dorsal white stripe and an orange-yellow tip.

The variety described by Fletcher and Hamilton (1887, p. 362) from Hyde Park, which did not possess the coloured anterior tip, must be regarded as a variety. The common Sydney variety with a mesial dorsal yellowish stripe must be regarded as still another variety of the species.

This species has been recorded from various places in Eastern Australia and from New Zealand. All workers draw attention to the very wide variation within the species. Dendy (1891, p. 124), in discussing this species, writes: "The ground colour of the dorsal surface (in life) ranged from pale indigo-blue to dark grey, blue-brown or almost black. The mid-dorsal yellow stripe was sometimes so pale as to be almost white, and frequently there was visible on each side an ill-defined dorso-lateral band of a lighter tint of the ground colour, dividing each half of the dark dorsal surface into a broader and a narrower band. The anterior extremity was pinkish, although sometimes the pinkish colour was scarcely recognizable. The ventral surface was bright blue, lighter in the mid line than elsewhere".

GEOPLANA CITRINA, n. sp. Text-fig. 2.

The dorsal and ventral surfaces of the body are clearly marked off from one another. The ventral surface is flat and of a uniform lemon colour. The dorsal surface is very convex and has a lemon ground colour, deeply mottled with sienna. There is a median dorsal stripe of ground colour, bounded on either side by a sienna stripe, definite on the inner border but merging into the sienna mottlings of the lateral regions of the dorsal surface. In spirit specimens the lemon colour becomes whitish. The eyes are arranged in three parallel rows on either side of the body, extending from the anterior end to about the middle of the body (Text-fig. 2).

A spirit specimen measures 9 cm. The mouth is small and situated in the mid ventral line, 51 mm. from the anterior end, and the genital aperture is 12 mm. posterior to the mouth.

Habitat.—Under rotten log, *Fagus* scrub, Barrington Tops.

This species resembles *Geoplana robusta* Steel in general shape, but is larger and has the lateral regions of the body irregularly mottled.

GEOPLANA BARRINGTONENSIS, n. sp.

The dorsal and ventral surfaces are not clearly marked off from one another. The ground colour is lemon. In the mid-dorsal line is a white stripe bordered on either side by pale sienna mottlings, which extend to the lateral regions of the body. The mottlings are so pale that they only add brightness to the lemon ground colour, making the median white stripe stand out more conspicuously.

The eyes are very numerous and are present as minute black specks placed ventro-laterally at the extreme anterior end, and extending round the horse-shoe shaped tip and along the whole length of the body to the posterior end. They are more numerous at the anterior end.

A spirit specimen measures 5·1 cm. The mouth is situated on the ventral surface 2·6 cm. from the anterior end; the genital aperture is 1·2 mm. behind the mouth.

Habitat.—On damp moss, Barrington Tops.

This species differs from *Geoplana fletcheri* Dendy in the possession of a median dorsal white stripe and in the absence of any coloration of the anterior tip.

ARTIOPOSTHIA HARRISONI, n. sp. Text-figs. 3, 4.

The ground colour of the dorsal surface is creamish-white. There is a wide median stripe of ground colour bounded on either side by a narrower black stripe with a definite median border and an indefinite lateral border. Laterally the body

is marked by a number of small dark brown spots. The ventral surface is white. At the anterior end the black stripes of the dorsal surface widen out, become brownish in colour and cover the lateral edges of the ventral surface (Text-fig. 3).

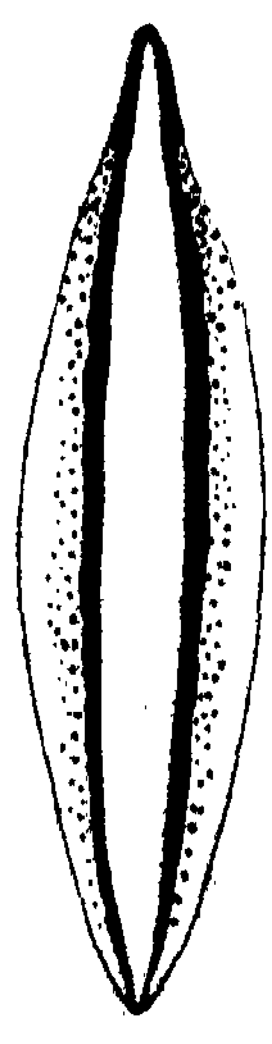
Spirit specimens measure 1·6 cm. The mouth is situated 7 mm. from the anterior end and the genital aperture is 3 mm. behind the mouth. Both apertures are extremely small.

Habitat.—On rock and on tree near Barrington River, Barrington Tops.

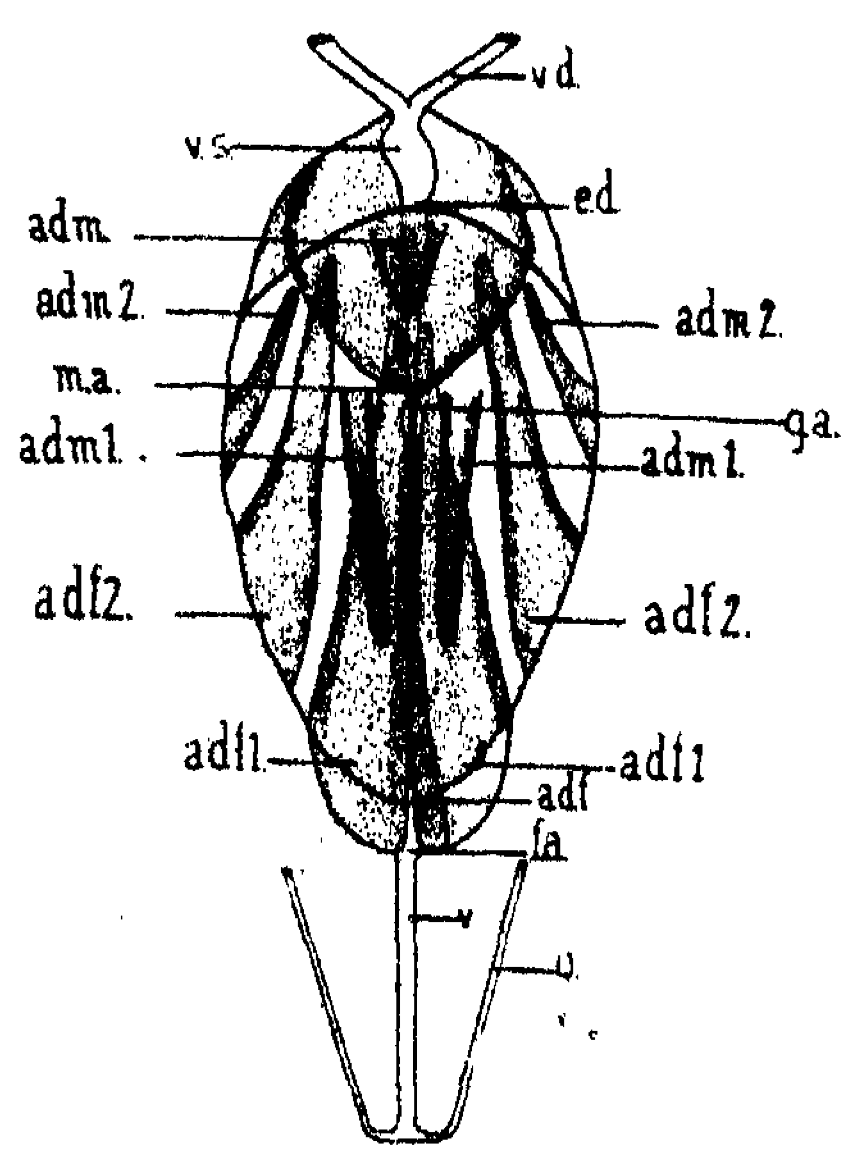
This species is unlike any described species of *Artioposthia*. It is very small and at first was taken for an immature specimen. Serial sections show it to be sexually mature.

In the generic synopsis (von Graff) given above, it will be noted that the genus *Artioposthia* is separated from the other genera of the family Geoplanidae because of the possession of muscular gland organs. These organs can be examined only by micro-dissection or by reconstruction of serial sections. The description given here has been worked out from a reconstruction of a series of transverse sections.

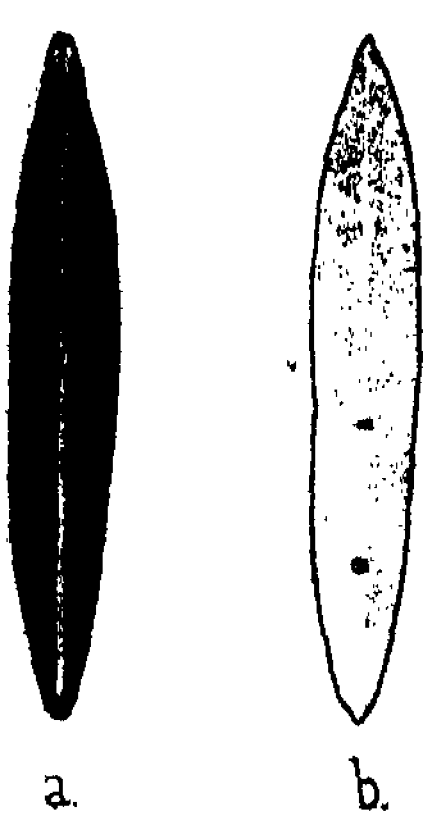
Male Organs (Text-fig. 4).—The two vasa deferentia (*v.d.*) unite just behind the pharyngeal region to form a slightly expanded vesicula seminalis (*v.s.*), which turns to the right and towards the ventral surface to open into the narrow



3.



4.



5.

Text-fig. 3. Dorsal surface of *Artioposthia harrisoni*.

Text-fig. 4. Reconstruction of genital organs in region of genital atrium of *Artioposthia harrisoni*. *adf.*, *adf1.*, *adf2.*, female adenodactyli; *adm.*, *adm1.*, *adm2.*, male adenodactyli; *f.a.*, aperture of vagina; *e.d.*, ejaculatory duct; *m.a.*, male aperture; *o.*, oviduct; *v.*, vagina; *v.d.*, vas deferens; *v.s.*, vesicula seminalis.

Text-fig. 5. *a.* Dorsal surface of *Platydemus assimilis*. *b.* Ventral surface.

glandular ejaculatory duct (*e.d.*), which passes back through the muscular penis to open into the genital atrium towards its dorsal wall (*m.a.*).

In addition to these copulatory organs there are a number of finger-like outgrowths from the wall of the genital atrium. These outgrowths are termed adenodactyli (von Graff). They vary in size and shape, but are arranged symmetrically in this species. There are five situated near the male aperture and five near the female aperture. The male adenodactyli are slender and short, the female adenodactyli are nearly all thick and long. In transverse section they show a central cavity surrounded by gland cells, which are enclosed in a muscular sheath.

The male adenodactyli are arranged around the male aperture. One arises from the ventral surface of the penis (*adm.*); it is short and thick, being not as long as the free portion of the penis. One pair arises from the dorsal surface of the genital atrium posterior to the common genital aperture (*adm1*). One pair arises from the side walls of the genital atrium (*adm2.*).

Female Organs.—The two oviducts, running from the ovaries at the anterior end of the body, swing in to the middle region of the body some distance behind the genital atrium, uniting to form the vagina (*v.*). The vagina runs forward to open into the posterior end of the genital atrium (*f.a.*).

There are five female adenodactyli. One pair arises from the side walls of the atrium just behind one pair of the male adenodactyli (*adf2.*). One pair arises from the posterior end of the genital atrium surrounding the aperture of the vagina (*adf1.*). The small unpaired one arises from the dorsal surface near the aperture of the vagina (*adf.*).

These adenodactyli fill the cavity of the genital atrium and may protrude through the genital aperture, which is situated in the ventral wall of the genital atrium just behind the aperture of the penis into the genital atrium.

Family Rhynchodemidae.

PLATYDEMUS ASSIMILIS, n. sp. Text-fig. 5.

The body is plano-convex, slightly flattened from above downwards. Dorsal and ventral surfaces are distinctly marked off from one another. The ground colour of the dorsal surface is very dark grey, almost black. There is a median dorsal black stripe, bounded on either side by a narrower light grey stripe. Laterally the dorsal surface is dark grey. At the anterior end the two light grey stripes widen out on their lateral margins, extending over the lateral regions of the anterior end. The ground colour of the ventral surface is a lighter grey. There is a median whitish stripe widening out at the mouth and genital aperture. There are two lateral whitish stripes, which are not clearly defined, separating the light grey of the ventral surface from the dark grey of the dorsal surface. The two eyes are borne on the dorsal surface, one on either side of the median black stripe, about 2 mm. from the anterior end (Text-fig. 5).

Spirit specimens measure from 2·1 cm. to 2·7 cm. In a specimen 2·1 cm. in length the mouth is situated 1·2 cm. and the genital aperture 1·7 cm. from the anterior end.

Habitat.—Under rotten log, Barrington Tops.

This species closely resembles *Platydemus victoriae* Dendy, but it has the stripes more clearly defined and is very much darker in colour.

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ANALYSES OF THREE AUSTRALIAN ROCKS.

By M. Aurousseau.

[Read 24th November, 1926.]

Samples of the three rocks with which this paper is concerned were obtained some years ago, on account of their unusual microscopical characters. They were put aside for examination when a favourable opportunity should occur, and were eventually analysed at the Geophysical Laboratory, Carnegie Institution of Washington, during the course of other work.

Nephelite-Basanite, One Tree Point, Hobart, Tas.

Specimens of this rock were collected for me by Professor Launcelot Harrison. It is the well-known blue metal of One Tree Point, Sandy Bay, Hobart, and has hitherto been called fayalite-basalt, or melilite-basalt. The occurrence in the field has been described and figured by Noetling[1]. A good deal of petrographical interest has been displayed in this rock, on account of the supposed occurrence of melilite in it, a mineral that is extremely rare in Australia. Petterd records not only melilite, but also haüynite, from the examination of thin sections[2]. Petterd and Twelvetrees have left behind them a volume of valuable work, and sound reputations for exactness. The determination of melilite, possibly on account of this recognized ability of the observer, has not hitherto been questioned, though others have admitted to me that they have been unable to find it when examining slices of the rock. An analysis of the material was made by White (?) and, though it is a poor analysis, it has not, astonishingly enough, thrown any suspicion on the supposed melilite. White and MacLeod state[3] that the rock is composed of fayalite (the formula of which they quote incorrectly), apatite, basic plagioclase, magnetite, and "glass". I propose to show that these determinations are wrong, and that the rock is a nephelite basanite containing iddingsite.

The Analysis.

An analysis was made, under the supervision of Dr. H. S. Washington, and gave such extraordinary results that the rock remains no less interesting than if it were a melilite-basalt. However, in order to demonstrate the impossibility of melilite occurring in a rock of such chemical composition, the average melilite-basalt, nephelite-melilite-basalt, and nephelite-basanite, were calculated, from the superior analyses available. Averages of this kind have already been computed by Daly,[4] but without regard to the minor constituents, which are here of great interest.

A glance at the table shows that the rock has no chemical affinity with the melilite-bearing rocks, and cannot therefore have any mineralogical affinity with them. Where are the lime and magnesia necessary for the formation of melilite? Where are the peculiar relations shown by such minor constituents as BaO, SrO, Cr_2O_3, Cl, CO_2, and water? The chemical affinities of the rock lie unquestionably with the nephelite-basanites, and it can be *generally* matched by the analysis of the nephelite-basanite of Otago. There are, however, certain peculiarities. The great preponderance of Fe_2O_3 over FeO, the low content of MgO, the high figures for water, the approximate equality of H_2O+ and H_2O-, the extraordinary amount of P_2O_5, the marked presence of SO_3 and Cl, etc., are all odd. But they are reflected in the mineral composition.

TABLE I.

	I.	II.	III.	IV.	V.	VI.	VII.	
SiO_2	45·59	47·21	49·93	44·76	37·28	35·99	or.	18·62
Al_2O_3	12·48	16·06	14·86	14·65	11·00	10·46	ab.	21·48
Fe_2O_3	9·93	11·87	7·58	4·66	6·93	5·40	an.	0·83
FeO	2·84	4·43	5·42	7·04	7·66	6·80	ne.	12·50
MgO	4·71	0·12	5·62	7·70	13·15	15·08	hl.	0·23
CaO	8·26	7·34	7·08	9·56	12·36	12·60	th.	0·10
Na_2O	5·51	7·51	4·71	4·19	3·88	3·08	di.	22·68
K_2O	3·16	2·40	2·54	2·20	1·49	1·91	ol.	1·68
H_2O+	1·73	2·55	2·52	1·36	1·76	2·03	mt.	3·71
H_2O-	1·64			0·29	0·80	0·34	il.	3·93
CO_2	none	—	—	—	0·23	0·49	hm.	7·36
TiO_2	2·10	—	—	2·55	2·40	4·25	ap.	3·86
ZrO_2	none	—	—	tr.	tr.	—	H_2O	3·37
P_2O_5	1·65	—	0·20	0·50	0·77	0·21		
SO_3	0·09	—	—	0·04	tr.	0·54		
Cl	0·16	—	—	—	tr.	tr.		
F	p.n.d.	—	—	—	tr.	—		
Cr_2O_3 ...	none	—	—	0·10	0·07	0·77		
MnO	0·16	—	—	0·26	0·16	0·05		
BaO	0·05	—	—	0·08	0·06	tr.		
SrO	n.d.	—	—	0·06	tr.	—		
NiO	n.d.	—	—	tr.	—	tr.		
Sum	100·06	99·49	99·69	100·00	100·00	100·00		100·35

I. Nephelite-basanite (so-called "fayalite-basalt", or "melilite-basalt"), One Tree Point, Sandy Bay, Hobart, Tasmania. M. Aurousseau, analyst.

II. The same, O. E. White, analyst (?). *Papers and Proc. Roy. Soc. Tas.*, 1898 and 1899 (1900), p. 78.

III. Nephelite-basanite, Otago, New Zealand. P. Marshall, analyst. *Q.J.G.S.*, vol. 62, 1906, p. 409.

IV. The average nephelite-basanite. Calculated from 12 superior analyses listed in *U.S.G.S.*, Prof. Paper 99, 1917.

V. The average melilite-nephelite-basalt. Computed from 6 superior analyses, *Ibid.*

VI. The average melilite-basalt. From 12 superior analyses, *Ibid.*

VII. Norm of I. Symbols: III.6.1.4. Pilandose.

The analysis presented by White and MacLeod is very defective. TiO_2 and P_2O_5, both present in unusually high quantity, were not determined at all, and are therefore represented in their figures for Al_2O_3. They record with astonishment only a trace of MgO. Evidently, the four and three-quarters per cent. of MgO which the rock contains, were precipitated with the alumina—a common pitfall in rock analysis. All this being so, why is their figure for alumina not higher? Potash was not properly determined. The figures given for water are stated in the original as "loss on ignition"—a method that gives poor results, especially in a rock containing so much iron. Finally, the sum is suspiciously low. With regret, I am forced to say that this analysis is valueless: but it would have been enough to throw suspicion on the supposed melilite.

The microscopical examination of the rock leaves little wonder that previous observers have encountered difficulty. Only two minerals are determinable by means of the microscope—iddingsite, and apatite—because they occur as what might be called "micro-phenocrysts". The mass of the rock is an ultrafine, welded felt of minute needles and interlocking grains, so fine that their optical behaviour is appreciably affected by the thickness of the slide.

Instead of the usual examination of thin slices, the mineral determinations were made by the "index" method, using Larsen's well-known tables. The material is powdered, and the powder examined under the microscope, in a graded series of liquids of known refractive indices. The refractive indices of each mineral are thus approximately determined.

Sulphate Vesicles.

Examination of the surface of the rock with a lens reveals a number of tiny vesicles, filled with a soft, greenish material. This filling was examined before the powder of the rock itself, and was found to consist principally of sulphate material. The same material surrounds, as a halo, several inclusions of quartz-andesine sandstone that were present in my specimens. Gypsum, thenardite, halite and sulpho-halite were all recognized, occurring in this manner, as well as a rod-like mineral that is present in so small an amount that it was only once observed, and then in a liquid inappropriate for its determination. The sulphate vesicles, and halos of similar material around inclusions, constitute only a small proportion of the bulk of the rock—perhaps no more than 0·4%, judging from the norm (Table I).

Mineral Composition.

Iddingsite is recognisable in the slides by its characteristic colour. It is pseudomorphous after olivine—perhaps after an iron-rich olivine, but not necessarily so. Each little pseudomorph has a border of darker colour than the interior. It is the "fayalite" of White and MacLeod[8]. The fact that iddingsite contains approximately equal amounts of H_2O+ and H_2O- is confirmation of its presence, for otherwise the water of the analysis, which must be nearly all contained in the iddingsite, would be exceedingly difficult to explain.

Apatite.—Micro-phenocrysts of apatite are abundant, and mineral makes up an appreciable bulk of the rock—nearly 4% according to the norm. Such a quantity of apatite is very unusual, and accounts for the high quantity of P_2O_5 in the rock. It is not a unique occurrence, however, as Washington has analysed basalts from the Hawaiian Islands that contain similar quantities of P_2O_5[9].

The mineral occurs here in hexagonal prisms that are well formed, and in thin sections is violet in colour, and shows slight pleochroism. It contains a number of black inclusions arranged parallel to the long axis. They seem to be earthy rather than metallic, and I have not been able to determine them. In outline they are rather ragged, and seem not to be magnetite.

White and MacLeod determined the apatite correctly, though it did not lead them to determine P_2O_5 in their analysis[3]. It is in this mineral, I believe, that the explanation of Petterd's determination of melilite and haüynite[2] is to be found. Its appearance is so unlike the ordinary apatite of igneous rocks; the crystals, compared with the texture, are so large, that it would be easy to regard the neat little hexagons and the long laths as two different minerals, the former haüynite, the latter melilite. There is, certainly, some resemblance to haüynite, but there is none to melilite, unless it be in the inclusions, which again, are not characteristically arranged.

Pyroxene occurs as a felt of fine, short, green needles in the groundmass. It has the extinction (from the elongation) of common pyroxene, which determination is confirmed by the indices. It is the labradorite of White and MacLeod.

Ilmenite.—The amount of TiO_2 renders it probable that the metallic dust scattered through the rock is ilmenite rather than magnetite. It occurs in rather large quantity.

The base.—The ultimate paste of the groundmass defies any precise analysis. It consists of an extremely fine and intimate mosaic, which is doubly-refracting throughout. It is the "glass" of White and MacLeod. It contains a good deal of an intermediate plagioclase and considerable nephelite. The norm shows 12½% of the latter, but the mode of the whole rock is so abnormative that no sound deduction can be made.

The Genesis of Iddingsite.

It must be remembered that the specimen analysed was quite fresh, containing not a trace of CO_2. All, or practically all of the water is accounted for by the iddingsite. This mineral, too, is not uniform in colour, but possesses a border zone, in every case of a deeper red-brown than the interior. On the extreme margins, this deeper zone is almost opaque. It points, possibly, to what might be termed "differential oxidation". That oxidation has been intense is shown by the excess of Fe_2O_3 in the analysis (by the very presence of iddingsite itself), and by the presence of 7% of hematite in the norm.

The pseudomorphs show no evidence of a long history of the alteration of olivine. They are free from signs of expansion, are clear-cut, idiomorphic, and the replacement is complete.

The rock contains small "sulphate vesicles" and aureoles of sulphur and halogen minerals around inclusions of fine-grained sandstone.

Finally, there are inclusions of apatite in the iddingsite, which are quite unaltered.

All these facts seem to me to be significant in the explanation of the genesis of iddingsite. They suggest that the iddingsite is the result of oxidizing processes that acted rapidly on the olivine, during the liberation of copious, active volatile phases at the time of eruption. No more can be deduced from the isolated

evidence of this one rock, especially without an analysis of the iddingsite itself. It would be almost impossible to isolate it free from inclusions and suitable for analysis.

Regional Affinities.

The nephelite-basanite of One Tree Point, Hobart, may be an isolated occurrence. It is more likely a regional expression. The supposed occurrence of melilite in it has caused it to be linked somewhat hazily with other Tasmanian rocks that undoubtedly do contain melilite. Actually, however, it bears not the slightest resemblance to the now famous melilite rocks of Shannon Tier[6], in which Bowen has recently shown that the lime olivine, monticellite, occurs[7].

The One Tree Point rock is more rationally regarded as a member of the alkaline suite of Tertiary eruptions that are so well developed in the neighbourhood of Port Cygnet[8]. Skeats has cleared up the question of the age of these rocks[9], and it is likely that further work will disclose other occurrences which are most suitably correlated with this series. There is, for instance, a nephelinite at Table Cape, Tas., of which the published section (unmeasured) seems to be identical with the measured section of the One Tree Point nephelite basanite given by Noetling[1].

Micrographic Granite, Ashford, N.S.W.

This rock was for long used as a type in the teaching of elementary petrology in the University of Sydney, on account of the rarity of muscovite in Australian granites. The material used here was obtained from the University, but unfortunately, it cannot be precisely localized. Years ago, a supply of the material was sent to the University, by a resident of Ashford, county of Arawatta, N.S.W., but the exact record of the spot where he obtained it seems to have been lost.

It is not part of the main mass of the Ashford batholith[11], for I have examined specimens in the private collection of Professor L. A. Cotton, from this source, and find them so unlike the rock under consideration that there is no possibility of confusion. From its appearance, this micrographic granite seems to be either a marginal modification or a hypabyssal intrusive—a dyke rock—and it is to be hoped that the occurrence will be rediscovered. In spite of the fact that it cannot be localized, I think that it is of sufficient importance to warrant a somewhat detailed consideration.

The rock is pink, and fine-grained, though not fine enough to be called a microgranite. On weathered surfaces it shows a thin crust that has been leached white. The best material can not be considered exceedingly fresh, but the alteration that has taken place is only slight. In thin section, it shows a most interesting series of intergrowths. Quartz is intergrown with orthoclase and muscovite. Muscovite and biotite lie in parallel position. There is, in general, such an interference of boundaries as to suggest that the crystallization of at least four minerals was simultaneous. There occur as well, albite, microcline, topaz, apatite, and pyrite, with a little limonite and kaolin. The phenomena of intergrowth are not evenly distributed, and are shown much more abundantly by some slides than by others. The fact that they are persistent in all slides shows that they run throughout the mass of the rock.

An analysis was made, and is shown in Table II. There is nothing unusual about the composition of this rock from the chemical point of view, and it can

be matched *generally*, by a plutonic, a hypabyssal, or an effusive rock, at choice, as the table shows. The curiosity lies in the extensive intergrowths.

In order to determine the proportions of the different minerals, and to ascertain the approximate amount of fluorine in the rock (an element whose gravimetric determination in small quantities is so unsatisfactory that the results of calculation are actually better), a series of Rosiwal measurements was made. There are two minerals of doubtful composition in the Ashford rock, the biotite and the topaz. Analyses of these two minerals were selected from the compositions tabulated by Iddings[19], care being taken to choose biotite and topaz from rocks of composition as nearly as possible like that of the Ashford rock. The biotite, for instance, is closer to that of El Capitan, Yellowstone National Park, U.S.A., than to any other available.

TABLE II.

	I.	II.	III.	IV.	V.	
SiO_2	76·02	77·28	76·10	74·22	Q.	38·34
Al_2O_3	13·25	11·90	13·45	12·98	C.	2·24
Fe_2O_3	0·61	1·30	1·34	0·40	or.	29·47
FeO	0·69	0·18	n.d.	1·60	ab.	25·68 } $=Ab_{94}An_6$
MgO	0·07	0·10	0·64	0·04	an.	1·67
CaO	0·51	0·80	0·42	0·67	di.	0·46
Na_2O	3·06	3·01	2·55	4·13	mt.	0·93
K_2O	5·11	5·26	5·01	4·97	il.	0·46
H_2O+	0·29	0·38	1·00	0·27	ap.	0·34
H_2O-	0·03	0·07		0·04	pr.	0·10
CO_2	none	none	—	—	H_2O	0·32
TiO_2	0·19	0·12	—	0·11		
ZrO_2	none	none	—	0·05		
P_2O_5	0·21	0·04	—	0·14		
SO_3	—	—	—	0·08		
Cl	n.d.	trace	—	0·03		
F	p.n.d.	none	—	—		
S	0·03	none	—	—		
Cr_2O_3	trace	none	—	—		
MnO	0·01	trace	—	0·01		
NiO	—	none	—	—		
BaO	—	none	—	none		
Sum	100·08	100·44	100·48	99·74		100·01

I. Micrographic granite, Ashford, New South Wales. M. Aurousseau, analyst.

II. Aplitic granite, Cove River, Bowenfels, New South Wales, Mingaye, analyst (?). *Ann. Rept. Dept. Mines, N.S.W.*, 1909 (1910), p. 198.

III. Porphyry, Marcillat, La Creuse, France. Pisani, analyst. L. de Launay, *Bull. Serv. Carte Géol. France*, vol. 11, 1902, p. 76.

IV. Obsidian, Rocche Rosse, Lipari. Washington, analyst. H. S. Washington, *Am. Journ. Sci.*, vol. 50, 1920, p. 449.

V. Norm of I. Symbols: I.3.1.3. Alaskose.

The corrected mode: inadequacy of Rosiwal analysis.

The measurements were made over a large series of slides, and a back-calculation of the composition of the rock was made from the mode so derived. Now, the minerals of this rock, except the biotite and topaz, are of simple and definite composition and the rock is holocrystalline. The albite has a composition close to that shown by the norm (Table II). It was expected, therefore, that the results of back-calculation would bear a close resemblance to the rock analysis. This was not the case, however, as witness the unexpected values obtained for the alkalis. The rock is not perpotassic, yet the calculation makes it appear so. These results are shown in Table III.

It was necessary to determine the reasons for this unexpected discrepancy. The values for SiO_2 in the rock analysis and the calculated composition are in close accord—a fact that shows that the actual *measurements* for quartz were accurately made. There is no reason to suspect the accuracy of the measure-

TABLE III.

	I.	II.	III.
SiO_2	76·02	75·70	76·43
Al_2O_3	13·25	12·70	12·86
Fe_2O_3	0·61	0·20	0·26
FeO	0·69	0·70	0·68
MgO	0·07	0·50	0·45
CaO	0·51	0·40	0·57
Na_2O	3·06	0·90	2·89
K_2O	5·11	8·20	5·24
H_2O+	0·29	0·30	0·27
H_2O-	0·03	—	—
TiO_2	0·19	0·05	0·05
P_2O_5	0·21	0·20	0·17
F_2	—	0·25	0·28
S	0·03	—	—
MnO	0·01	tr.	0·04
Sum	100·08	100·10	100·19
Less O_2 ...	—	0·10	0·12
	100·08	100·00	100·07

I. Composition, determined from rock analysis.
II. Composition calculated from Rosiwal measurements.
III. Composition calculated from corrected mode.

ments for microcline, muscovite, biotite, topaz, or the accessories. This throws the onus of inaccuracy on to the orthoclase and the albite, two minerals of simple and known composition. The matter was discussed with Dr. N. L. Bowen, who stated orally that in his experience, Rosiwal measurements involving orthoclase and albite are quite likely to be erroneous, on account of the similarity of the refractive indices of the two minerals, and the fact that many sections of albite may not appear to be twinned. He added, that the confusion can be partly avoided by careful adjustments of illumination.

If illumination is to be adjusted for every grain that appears to be orthoclase, the process of measurement becomes painfully slow. Now, the minerals involved

are of known composition, and the plagioclase is normative. It was, therefore, possible to make an adjustment, using both the norm, and the measured mode, between the molecules muscovite, orthoclase, microcline, albite, and anorthite. Muscovite and microcline were measured, and there is no reason to believe that they were incorrectly measured. The quantities of orthoclase + microcline (involving muscovite) are ascertainable from the norm (Table II). Thus, correct figures for modal orthoclase and microcline are ascertainable. They leave a difference which represents modal albite—a figure slightly lower than that for normative albite, on account of the presence of biotite. The results of measurement and the corrected mode are shown in Table IV.

The test of the accuracy of these adjustments is in the back-calculation of the composition of the rock, from the corrected mode. Allowing for the fact that the composition of the biotite is *assumed*, the composition so calculated is as close as could be desired to the rock analysis (column III of Table III). These results show that about 16% of albite was measured as orthoclase.

TABLE IV.

Mineral.	Vol. %	Density	Wt. %	Corrected
Quartz	38·9	2.66	39·3	39·3
Orthoclase	33·6	2·54	32·3	16·3
Albite	8·6	2·67	8·7	24·7
Microcline	10·2	2·54	9·8	9·8
Muscovite	3·1	2·88	3·4	3·4
Biotite	4·2	2·90	4·6	4·6
Topaz	1·0	3·55	1·4	1·4
Apatite	0·4	3·20	0·4	0·4
Pyrite, Limonite, Kaolin	—		—	0·1
Sum	100·0		99·9	100·0

Composition of the biotite.

From the results of the analysis and the corrected mode, it is possible to arrive at some conclusions concerning the actual composition of the biotite of the rock. It must be remembered that the material is not quite fresh, and that alteration affected the biotite more than the other minerals. Moreover, the quantity of biotite is small (4·6%). There is also the question of solid solution, which renders it likely that a little excess Na_2O belongs to orthoclase or microcline. Some excess Al_2O_3 must go to topaz. Some Fe_2O_3 undoubtedly belongs to limonite. I endeavoured to calculate a probable composition for the biotite, but it does not justify publication. It may be said with some confidence, however, that the biotite of the Ashford rock contains practically no lime, and has less SiO_2, MgO and K_2O, and more Al_2O_3, Na_2O, H_2O, TiO_2, and MnO, than the selected biotite of El Capitan. The differences are greatest in lime, magnesia, soda, and titania. They seem to amount

TABLE V.

Mineral	%	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O+	H_2O-	TiO_2	P_2O_5	F_2	S	MnO	Less O_2	Sum
Quartz	39·3	39·30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Orthoclase..	16·3	10·55	3·00	—	—	—	—	—	2·75	—	—	—	—	—	—	—	—	
Albite	24·7	16·57	4·09	—	—	—	0·32	2·72	—	—	—	—	—	—	—	—	—	
Microcline..	9·8	6·34	1·80	—	—	—	—	—	1·66	—	—	—	—	—	—	—	—	
Muscovite ..	3·4	1·54	1·31	—	—	—	—	—	0·40	0·15	—	—	—	—	—	—	—	
Biotite	4·6	1·66	0·87	0·26	0·68	0·45	0·03	0·17	0·43	0·12	—	0·05	—	0·01	—	0·04	0·01	
Topaz	1·4	0·47	0·79	—	—	—	—	—	—	—	—	—	—	0·25	—	—	0·10	
Apatite	0·4	—	—	—	—	—	0·22	—	—	—	—	—	0·17	0·02	—	—	0·01	
Pyrite, Limonite, Kaolin ..	0·1	—	—	0·35	0·01	—	—	—	—	0·02	0·03	—	—	—	0·03	—	—	
Totals	100·0	76·43	12·86	0·61	0·69	0·45	0·57	2·89	5·24	0·29	0·03	0·05	0·17	0·28	0·03	0·04	0·12	
Analysis ...	—	76·02	13·25	0·61	0·69	0·07	0·51	3·06	5·11	0·29	0·03	0·19	0·21	—	0·03	0·01	—	100·08
Differences— (+)	—	—	0·39	—	—	—	—	0·17	—	—	—	0·14	0·04	—	—	—	—	
(−)	—	0·41	—	—	—	0·38	0·06	—	0·13	—	—	—	—	—	—	0·03	—	

in general to ±3%, but in the case of MgO the difference is about 8%. The composition, nevertheless, is close to that of the biotite chosen.

The "complete" statement of a rock.

From the foregoing sections it is evident that we have here rather complete information about an igneous rock—a chemical statement which takes into account all the minor constituents that are of importance in this kind of rock, and a statement of the mode that approximates closely to the truth. The requirements of petrological chemistry are becoming more and more exacting, and it is desirable to know not only the bulk composition of the rock, but also the composition (and in many cases the proportions) of the phases. This should also be determined whenever possible by chemical analysis. The amount in which each phase appears can be deduced easily, if an analysis of each phase is made. It can also be determined by Rosiwal measurements, for holocrystalline rocks. Analysis of the minerals is preferable, as the ultimate aim is to obtain information as to how the various oxides are distributed among the phases. It is from the holocrystalline rocks of not too fine a grain that important contributions are likely to come, for with them, the phases can be isolated for analysis, and the Rosiwal measurements can easily be made. This "complete" investigation of the chemistry of rocks is seldom made. I have, with Eskola, made a study of the kind, on an olivine-diabase from Ylane, Finland, the results of which are not yet published. I present, here, however, a statement of the chemistry of the Ashford rock (Table V) as a contribution to method. Statements of this kind, if based wholly upon analysis, as is the case with the Finnish olivine-diabase, should represent a distinct advance over the ordinary method of presenting rock analyses, for they show not only what the oxides are, but also, what is more important, *where* they are.

The phenomenon of Graphic Intergrowth.

The only reason for studying the Ashford rock was the occurrence in it of a complicated form of graphic intergrowth. The whole question of graphic and micrographic intergrowth seems to have departed from the simple "eutectic" explanation, and to have entered the realm of suspended judgment. Van der Ween has shown that the eutectic explanation will not hold for the pegmatites[13], and that different observers have recorded divergent values for the ratio quartz: orthoclase. He shows, too, that there is a kind of crystallographic sympathy between quartz and orthoclase in some positions, and explains the phenomena of intergrowth as the results of competition during crystallization. Fersman, too, has interpreted the matter on crystallographic grounds[14]. Schofield investigated the micropegmatite of the Purcell Sills, and concluded that the gabbro and micropegmatite of the composite sills are gravitative differentiates in place, and that in the latter the quartz holds the feldspar[15]. These studies seem to point towards crystallographic forces, and chance orientation of grains in the magma, as the explanation of intergrowth. There is, however, the possibility of intergrowth by replacement. This has been demonstrated in the case of certain ore deposits, where chalcocite, in graphic intergrowth, has arisen by the replacement of bornite and chalcopyrite[16], but so far, no such evidence has been produced for the non-metallic minerals of the igneous rocks.

That there is no constancy of composition in granitic rocks showing intergrowth is easily demonstrable. Analyses of graphic granite, pegmatite, and granophyre, show a great deal of divergence in composition. The micropegmatite of the Purcell sills for example[16] is a rock which is less silicic, less alkalic, and richer in FeO, MgO, and CaO than the Ashford rock. No simple explanation is likely to be forthcoming from a study of chemical composition alone. There is the possibility of intergrowth by replacement, easily conceivable for related molecules like orthoclase and muscovite, but it is not so easy to imagine for muscovite and quartz, or for orthoclase and quartz. Why, too, in the Ashford rock, should quartz, orthoclase, and muscovite all show intergrowth, and the two micas at the same time crystallize in parallel position?

We are forced to accept Van der Ween's idea of crystallographic sympathy and competing growth, as part of the general explanation. But it implies simultaneous crystallization of the two or more intergrown phases, and this cannot fail to have some physico-chemical significance in the history of the magma. The simultaneous crystallization of four phases, in the Ashford rock, is surely an index to a critical stage in the consolidation of the magma to which it belonged. In the terminology of poly-component systems, the Ashford rock probably represents crystallization along a boundary line.

Amphibolite. Bunker Bay, Cape Naturaliste, W.A.

This rock forms a prominent dyke-like outcrop, running from the beach out into the sea, in a northerly direction, on the west side of Bunker Bay, under the lee of Cape Naturaliste. For a short distance it forms a kind of causeway. Owing to its deep, almost black colour in the mass, it stands out prominently from the gneisses, and is easily recognizable. In hand specimens it is a handsome rock, having an even grainsize, and a colour and texture that recall very dark brown sugar. The dyke-like mass is even in composition, and shows no pronounced evidence of foliation, although the strike is concordant with that of the gneisses in which it occurs.

Thin slices were as puzzling as the hand specimens. The texture is that of a granulite, and is even in grainsize, and regular in the rounded form of the grains. The mineral composition is simple. The most abundant mineral is a brown hornblende, deep in colour, and strongly pleochroic. Next in quantity is a rhombic pyroxene, lighter in colour than the hornblende. The plagioclase is decidedly basic, and has unusually broad twin-lamellae. Quite large grains of ilmenite are common, and there is a little apatite, but no garnet was observed. An analysis (Table VI) was necessary before the rock could be satisfactorily classified.

The rock is an amphibolite, differing very little in chemical composition from the common, green amphibolites. It fits well into the "amphibolite facies" of Eskola[17]. There is nothing remarkable about the chemical composition except the high quantity of TiO_2 which is a feature it shares with many other Western Australian rocks. Moreover, ilmenite sands are common along that part of the coast from which this rock comes. The sulphur and chlorine possibly represent contamination by sea water, as the whole outcrop is exposed to the sea.

The sum of the analysis appears low. Fluorine, however, was not determined, and, as the principal mineral of the rock is a brown hornblende, there must be an appreciable quantity of fluorine present.

The rock belongs to a complex metamorphic series that has been reconnoitred by Saint-Smith[18]. The exposures at Bunker Bay are admirable and should attract the attention of a student of metamorphism who wishes to make an intensive study of a small area. None could be more suitable than Bunker Bay.

TABLE VI.

		mol. prop.
SiO_2	47·88	798
Al_2O_3	14·22	139
Fe_2O_3	1·73	011
FeO	12·36	172
MgO	6·35	134
CaO	10·28	183
Na_2O	2·47	040
K_2O	0·51	005
H_2O+	0·23	—
H_2O-	0·07	—
CO_2	none	—
TiO_2	2·95	037
ZrO_2	none	—
P_2O_5	0·40	004
Cl	0·08	—
F	p.n.d.	—
S	0·08	—
Cr_2O_3	trace	—
BaO	trace	—
	99·71	
Less O_2 ...	0·05	
Sum	99·66	

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THE GASTEROMYCETES OF AUSTRALASIA.

vi. THE GENUS LYCOPERDON.

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(Plates xlvi-xlviii.)

[Read 24th November, 1926.]

Lycoperdon is a cosmopolitan genus of about thirty species, found in practically every country in the world, though most abundant in temperate regions.

Prior to 1890, workers included in the genus plants belonging to most of the genera now placed in the Lycoperdaceae, together with others since placed in different families and orders. At this date, Morgan (1890) published a paper in which he so clearly defined the limits of the genus and determined its relationships, that his arrangement has been generally followed by later workers, though a few European mycologists still differ somewhat, especially in not recognizing *Calvatia* as a separate genus.

Others again would still further emend *Lycoperdon*. For example, a recent North American worker has taken certain plants from *Lycoperdon* and placed them under *Bovistella*, solely because they possessed pedicellate spores. Now the main character separating *Bovistella* from *Lycoperdon* is the peculiar nature of the capillitium, pedicellate spores being either present or absent in different species of the genus. The species in question all possess *Lycoperdon* capillitia, consequently if this worker's ideas were to be followed, the generic characters of both *Bovistella* and *Lycoperdon* would be broken down.

The genus has usually been considered a difficult one for the systematist. This has arisen partly as a result of the variable nature of many of the species.

Many of the earlier workers apparently held a fixed belief that any plant from a new country must necessarily be new. Consequently we find that practically every collection sent from Australia and New Zealand to England during the last century was named as new and listed accordingly. This will be made apparent by a perusal of the list of rejected species at the end of this paper. Again, it was the practice of most of the earlier systematists to erect species upon characters which are now known to be highly variable—as, for example, the colour, size and shape of the peridium, colour of the gleba and nature of the exoperidium. Consequently as the species have become better known it was found that many so-called species were but forms of already well-known species, differing in that they were of a slightly different shape, size, colour, or possessed a more or less strongly marked exoperidium. This variability is well illustrated in *L. depressum*, where individual plants in the same collection may be cream, yellow, bay-brown or umber; globose, obconic, elliptical or subturbinate; from 1 to 5 cm. in diameter; and the exoperidium may be of long and slender single spines, of cruciate spines, of small flattened verrucae, and even of small granules, definite spines being absent. If solitary plants of this species were encountered, workers too frequently,

noticing that they differed from the typical form, considered them as separate species and accordingly named them as new. And this may be said to have happened with most of the common species.

It has been considered unnecessary to arrange the species under sections, as is usually done, for this serves no useful purpose, but on the contrary too often tends to confusion, owing to the fact that species of this genus do not fall into well-defined groups, but tend to merge into one another.

Structure of the Mature Plant.

The plant consists of a prominent peridium of two layers (exoperidium and endoperidium) which merges into either a stem-like base or a long and slender rooting base, not unlike a tap-root in appearance. Enclosed within the peridium is a gleba, of capillitium and spores, and the lower portion is usually occupied with a prominent cellular base.

The exoperidium is of the nature of a fugacious, pseudoparenchymatous structure, which may consist of long, single or cruciate spines, verrucae, flattened verrucae or may be furfuraceous or even tomentose. In the past most species were erected upon the nature of the exoperidium, but this is perhaps the most variable character of the genus, consequently, unless well marked, should be considered of doubtful specific import. An example of this variability occurs in *L. depressum*, where the exoperidium in different plants of the same collection may be spinose, verrucose, furfuraceous or almost smooth. The exoperidium is usually fugacious, but may be partly persistent, as is frequent with *L. piriforme* and *L. compactum.*

The endoperidium persists during the lifetime of the plant, and may be tough and membranous, the common condition, or flaccid and papyraceous (*L. spadiceum*, *L. pusillum*). It is usually smooth, but may be reticulated (*L. compactum*), due to the persistence of granules of the exoperidium, or covered with minute depressions like the head of a thimble (*L. subincarnatum*). It is perforated apically with a solitary, plane or erumpent stoma, differing in this respect from *Calvatia*, where dehiscence is effected by the falling away of the apical portion of the endoperidium. In *L. depressum* a stoma first appears, but is shortly followed by the disappearance of the apical portion of the peridium, as in *Calvatia*. Confusion would arise as to the generic position of this species only with old and weathered specimens; in such cases the hyaline, freely septate capillitium would show its position, being peculiar to two other species of *Lycoperdon*, *L. compactum* and *L. subincarnatum*, but not known to be present in any species of *Calvatia*.

The sterile base is usually cellular, but in *L. polymorphum* is compact and formed of interwoven hyphae of the glebal type. In two species (*L. pusillum* and *L. Gunnii*) it is absent.

The cells of the sterile base are of two types: large and readily seen with the unaided eye, and minute, when they are just perceptible. In one species, *L. depressum*, is present a prominent diaphragm which separates the sterile base from the gleba.

The gleba, of spores and capillitium, offers some of the best specific characters present in the genus. The capillitium threads may be simple, hyaline and freely septate (*L. depressum*, *L. compactum* and *L. subincarnatum*); coloured, continuous and simple or sparingly branched (*L. piriforme*, *L. perlatum*, *L. stellatum*, *L. nitidum* and *L. Gunnii*); or coloured, continuous and freely

branched (*L. spadiceum*, *L. polymorphum*, *L. pusillum*, *L. glabrescens*, *L. scabrum* and *L. asperum*), when they superficially resemble those of the genera *Bovista* and *Bovistella*. This resemblance is merely superficial, however, for the peculiar threads of the latter two genera may readily be segregated, mounted and photomicrographed, a procedure not possible with those of *Lycoperdon*. In certain species the threads are at intervals perforated with conical pits extending to the lumen; a character which is also present in the threads of species of both *Bovista* and *Bovistella*.

A columella, formed of sterile tissue, is present in a few species (*L. piriforme*, *L. perlatum* and *L. compactum*).

The spores are usually globose, continuous, coloured and finely verruculose, though a few species possess verrucose spores. In four species (*L. glabrescens*, *L. Gunnii*, *L. scabrum* and *L. asperum*) the spores are provided with long (10-15 μ) acuminate pedicels. These are in reality the long sterigmata of the basidia, which have persisted after the breaking up of the tramal plates. Such spores are said to be pedicellate; if stumps only of the sterigmata persist attached to the spores, the latter are said to be apiculate; if neither pedicels nor stumps are present on the mature spores they are said to be apedicellate.

Most species grow upon the ground in pastures or in vegetable debris on the forest floor, but three species (*L. piriforme*, *L. compactum* and *L. subincarnatum*) grow upon rotting wood, a habitat which should aid in diagnosis of these three species.

Further details of the structure and development of a species of the genus may be obtained from a recent paper by the writer (1926).

Thanks are again due to Dr. J. B. Cleland, The University, Adelaide, Mr. C. C. Brittlebank, Melbourne, and Mr. L. Rodway, Hobart, for the loan of specimens of the genus in their possession; and to Mr. H. Drake of the Biological Laboratory, Wellington, for several of the photographs reproduced herein.

LYCOPERDON Tournefort ex Persoon.

Syn. Meth. Fung., 1801, p. 138.—*Utraria* Quel., *Bull. Soc. Myc. Fr.*, xxiv, 1876, p. 366.—*Globaria* Quel., *l.c.*, p. 370.

Peridium variously shaped, with a prominent stem-like base or rooting strand; of two layers, a fugacious exoperidium which is pseudoparenchymatous and warted, spinose or granular; and a persistent endoperidium which is membranous or papyraceous, thin, tough, and dehisces by a solitary apical stoma; sterile base present or absent; diaphragm present or absent.

Gleba of capillitium and spores; columella present or absent; capillitium threads long, simple or branched, continuous or septate, hyaline or coloured, attached by one end to the endoperidium, or columella, when present. Spores globose or shortly elliptical, continuous, rough or smooth, coloured, pedicellate or not. Basidia long-sterigmate, 4-spored.

Habitat.—Solitary, in groups, or caespitose on the ground or upon rotting wood, stumps, etc. in pastures or the forest.

Distribution.—World-wide.

Owing to the differences of opinion among systematists as to the specific value of many of the characters discussed, no definite idea as to the number of species extant may be obtained. For example Massee (1887) considers no less than 129 species. Probably the real number is in the vicinity of 30, of which 14 are present in Australia and New Zealand.

Key to the Species.

A. Spores without distinct pedicels.	
a. Capillitium hyaline, freely septate.	
(*a*) Diaphragm present	1. *L. depressum.*
(*b*) Diaphragm absent.	
1. Endoperidium with numerous minute depressions	2. *L. subincarnatum.*
2. Endoperidium reticulate with persistent granules	3. *L. compactum.*
b. Capillitium coloured, usually continuous.	
(*a*) Capillitium continuous or sparsely branched.	
* Sterile base of large cells, 2 mm. or more.	
1. Exoperidium of minute connivent spines	4. *L. piriforme.*
2. Exoperidium of conspicuous pointed verrucae	5. *L. perlatum.*
** Sterile base of minute cells, 1 mm. or less.	
1. Exoperidium of large cruciate spines	6. *L. stellatum.*
2. Exoperidium furfuraceous	7. *L. nitidum.*
(*b*) Capillitium freely branched.	
1. Sterile base cellular	8. *L. spadiceum.*
2. Sterile base compact	9. *L. polymorphum.*
3. Sterile base absent	10. *L. pusillum.*
B. Spores long-pedicellate.	
a. Sterile base well developed.	
1. Exoperidium furfuraceous	11. *L. glabrescens.*
2. Exoperidium of cruciate spines	12. *L. scabrum.*
b. Sterile base scanty or absent.	
1. Exoperidium of pallid, cruciate spines	13. *L. asperum.*
2. Exoperidium furfuraceous or tomentose	14. *L. Gunnii.*

1. Lycoperdon depressum Bonorden. Plate xlvi, figs. 1-3.

Bot. Zeit., 1857, p. 611.—*L. natalense* Cke. et Mass.; Mass. in *Jour. Roy. Micr. Soc.*, 1887, p. 709.—*L. Kalchbrenneri* de Toni, in Sacc. *Syll. Fung.*, vii, 1888, p. 109.

Peridium yellow, becoming pallid brown, up to 5 cm. diam., elliptical, obconic or sub-turbinate, frequently constricted and plicate towards the base; exoperidium of white spines united at their apices, immixed with numerous simple spines and granules; larger and more numerous apically, partially disappearing with age; endoperidium ochraceous or bay brown, dehiscing by a definite apical stoma, later the whole of the apical portion falling away; sterile base occupying the lower third of the peridium, of large cells, bay- or umber-brown, separated from the gleba by a well-defined diaphragm.

Gleba yellowish, becoming pallid olivaceous; columella absent; capillitium threads hyaline, simple or sparingly branched, not pitted, septate. Spores globose, 3·5-5·5 μ diam., apedicellate; epispore pallid olivaceous, finely and closely verrucose.

Habitat.—Solitary or in small groups on the ground, often forming rings in pastures.

Distribution.—Britain; Europe; South Africa; Australia; Tasmania; New Zealand.

Victoria: *Ararat, May, 1918, E. J. Semmens; *Melbourne, May, 1910.

New South Wales: *Leura, June, 1916.

South Australia: *Mt. Lofty, Apl., 1917 (2 coll.); *National Park, June, 1917; May, 1921 (3 coll.); May, 1920 (Det. Lloyd No. 643 as *L. Wrightii*); *Beaumont, Apl., 1920; May, 1923; June, 1921; May, 1925; *Encounter Bay, Jan., 1923 (4 coll.);

* An asterisk indicates that the collection in question is in the herbarium of Dr. J. B. Cleland, Adelaide; and where the collection is preceded by an asterisk, but no collector given, it signifies that the collection was made by Dr. Cleland himself.

** A double asterisk preceding a collection indicates that the collection in question is in the herbarium of the writer; and where no collector is given, signifies that the collection was made by the writer himself.

*Adelaide, July, 1922; *Eagle on Hill, June, 1921; *Kuitpo, May, 1921; *Upper Sturt, May, 1920; *Mylor, May, 1925; *Bulls Creek, Dec., 1921.

New Zealand: *Queenstown, May, 1922 (Lloyd No. 863 as *L. cruciatum*); **Rotorua, J. Barr, June, 1919; **Tasman, Feb., 1920; **Mapua, May, 1922; **Tapanui, Mar., 1923; **Dun Mt., Nelson, June, 1923, J. C. Neill; **Whakatikei, June, 1923, J. C. Neill; **Weraroa, May, 1924; Mar., 1925, J. C. Neill; **Ashburton, Jan., Feb., Mar., Aug., 1925, J. C. Neill; **Pencarrow, Mar., 1926, J. C. Neill.

The species is characterized by the prominent diaphragm, large cellular base and hyaline, septate, simple or sparingly branched capillitium. It is the most abundant Australian and New Zealand species, is apparently common in Europe, but strangely absent from North America, where it appears to be replaced by a form Lloyd (1905*b*) has named *L. subpratense*, separated by its coloured capillitium.

Lloyd has recorded both *L. Wrightii* Berk. and *L. candidum* Pers. (= *L. cruciatum* Rostk.) as occurring in Australasia, but examination of specimens so determined by him in the collections of Dr. Cleland, show them to be *L. depressum*.

Lloyd (1905*c*) states that he believes this species is probably *L. hiemale* Vitt., and possibly *L. pratense* Pers., but has produced no evidence in support of his statement; nevertheless, the species is regularly discussed in his works under the latter name.

2. Lycoperdon subincarnatum Peck. Plate xlvi, figs. 4-5.

N.Y. Nat. Hist. Mus. Bot. 24th Rept., 1872, No. 82.—*L. tephrum* Berk. in Herb.; Mass., *Jour. Roy. Micr. Soc.*, 1887, p. 723.

Peridium up to 2 cm. diam., depressed-globose or shortly sub-pyriform, tapering abruptly into a short, stem-like base, attached to the substratum by numerous conspicuous, white mycelial strands; exoperidium of minute, partly fugacious, fasciculate, nodose spines, more prominent apically; endoperidium tough, membranous, darker apically, covered on the apical portion with minute depressions, appearing somewhat reticulate in consequence; sterile base scanty or absent, compact, pallid; diaphragm absent.

Gleba olivaceous, becoming umber; columella absent; capillitium simple or sparingly branched, hyaline, septate, not pitted, about twice the diameter of the spores. Spores globose, apedicellate, 3·4-4 μ diam.; epispore pallid olive, delicately verruculose.

Habitat.—On decaying wood on the forest floor.

Distribution.—North America; Australia.

New South Wales: *Bulli, Apl., 1910 (Det. Lloyd as *L. purpureum*); *Lisarow, June, 1916; *National Park, July, 1916; *Mt. Irvine, June, 1915.

Characterized by the peculiar pitted nature of the upper portion of the endoperidium, the hyaline, septate capillitium and very scanty, compact sterile base (which in some specimens may be absent). The habitat—decaying wood—is also characteristic, being peculiar to only two other Australasian species, *L. piriforme* and *L. compactum*, and should aid in diagnosis.

Lloyd has named one of the above collections as being *L. purpureum*, but in a later paper has shown that this was a misdetermination.

3. Lycoperdon compactum G. H. Cunn. Plate xlvi, figs. 6-7.

Trans. N.Z. Inst., lvii, 1926, 195.

Peridium up to 4 cm. diam., subglobose or pyriform, depressed above, compressed below into a short, stem-like base; exoperidium of strong brown spines, 3-4 mm. long, separate at the base, frequently connivent at the apices, surrounded by a ring of minute brown warts or granules, the spines partially disappearing with age, when the endoperidium appears reticulate from the presence of the persistent rings of granules; endoperidium membranous, ochraceous, becoming brown, dehiscing by an apical, plane, torn stoma; sterile base occupying the stem-like base, often rudimentary, minutely cellular, ochraceous; diaphragm absent.

Gleba olivaceous, pulverulent; columella small, elliptical; capillitium threads hyaline, sparsely branched or simple, septate, diameter of the spores, not pitted. Spores globose, 3·5-4·5 μ, with caducous pedicels up to 5 μ long; epispore olivaceous, closely and finely verrucose.

Habitat.—In small groups or caespitose on rotting wood on the forest floor.

Distribution.—New Zealand.

**Lake Papaetonga, Aug., 1919 (Det. Lloyd as *L. piriforme. Sic.*); **York Bay, Wellington, Feb., 1923, E. H. Atkinson (Type coll.).

The species is characterized by the spinous exoperidium, minutely cellular sterile base, hyaline, septate capillitium, and finely verrucose spores. It is peculiar in that it possesses certain characters of several species, for it has the exoperidium of *L. echinatum* Pers., compact, sterile base of *L. Hoylei* Berk., spores of *L. perlatum* Pers., and capillitium of *L. depressum* Bon.

The exoperidium is clothed with long (3-4 mm.), dark brown, almost black spines, which are free at their bases, but frequently connivent at their apices; at the base they are surrounded with a ring of numerous, coloured granules. When the spines fall away, as they do as the plant ages, the endoperidium appears reticulate, owing to the presence of these rings of granules, which persist and form a net-like series of fine lines.

The habit of growing upon wood is also a feature of the plant, being peculiar to only two other Australasian species, *L. piriforme* and *L. subincarnatum*.

4. Lycoperdon piriforme Schaeffer ex Persoon. Plate xlvii, figs. 8-9.

Syn. Meth. Fung., 1801, p. 149.—*L. piriforme* var. *flavum* Lloyd, *Letter No. 60*, 1915, p. 11.

Peridium up to 10 cm. diam., grey to bay brown, pyriform, subturbinate or subglobose, with a compressed, slender, stem-like base; exoperidium of minute, scattered, brown or black, hemi-persistent, pointed verrucae and granules; endoperidium brown, membranous, dehiscing by an apical, small, plane, torn stoma; sterile base prominent, forming the stem-like base, cells large, pallid tan or yellowish; diaphragm absent.

Gleba greenish-yellow, becoming ferruginous or olivaceous; columella prominent, subglobose; capillitium threads olivaceous, sparingly branched or simple, continuous, not pitted, thick walled, about the diameter of the spores. Spores globose, 3·5-4·5 μ diam., apedicellate; epispore pallid olivaceous, finely verruculose.

Habitat.—Solitary, in groups, or caespitose on rotting wood on the forest floor, or on decaying logs and stumps.

Distribution.—Britain; North and South America; Europe; India; Japan; Australia; Tasmania; New Zealand.

Queensland: *Bunya Mts., Oct., 1915.

New South Wales: *No locality (4 collections).

South Australia: *Beaumont, May, 1923.

Tasmania: Hobart, L. Rodway, Herb. Nos. 1412, 1416.

New Zealand: **Lake Papaetonga, Aug., 1919; **Pokaka, Waimarino, Feb., 1922, D. Miller; **Weraroa, Aug., 1919; May, 1923; **Whakatikei, June, 1923, J. C. Neill; **Day's Bay, Apl., 1926, D. W. McKenzie.

Characterized by the minute verrucae of the exoperidium, the (usually) pyriform shape, finely verruculose spores and habit of growing upon rotting wood. It is liable to confusion only with *L. perlatum*, from which it may readily be separated by these characters.

4a. LYCOPERDON PIRIFORME var. SEROTINUM (Bon.) Hollos.

Gast. Hungary, 1904, p. 112.—*L. serotinum* Bonorden, *Bot. Zeit.*, 1857, p. 631.

Exoperidium persistent and broken into small areolae, giving to the peridium a reticulated appearance. Spores perfectly smooth. Other characters as above.

Distribution.—Britain; Europe; North America; Australia.

New South Wales: *Macquarie Pass, Aug., 1917.

The smooth spores are a distinctive feature of this collection, and the plant is really worthy of specific rank on this account, but as the writer has seen only one specimen, he cannot say whether this is a constant feature, so for the time follows Hollos in considering this a variety of *L. piriforme*.

5. LYCOPERDON PERLATUM Persoon. Plate xlvii, figs. 10-11.

Syn. Meth. Fung., 1801, p. 148.—*L. gemmatum* Batsch ex Auctt.—*L. excipuliforme* (Scop.) Vitt., *Mon. Lyc.*, 1842, p. 193.—*L. montanum* Quel., *Champ. Dura*, 1876, p. 444.—*L. Colensoi* Cke. et Mass.; Mass. in *Jour. Roy. Micr. Soc.*, 1887, p. 711.—*L. tasmanicum* Mass., *Kew Bull.*, 1901, p. 158.—*L. macrogemmatum* Lloyd, *Myc. Notes*, 1906, p. 265.

Peridium up to 6 cm. diam., yellowish, becoming bay brown, subglobose, pyriform or turbinate, often tapering into a cylindrical, stem-like base; exoperidium of white, pointed verrucae, surrounded by a ring of smaller warts and granules, which give a reticulated appearance to weathered specimens; endoperidium bay brown, membranous, dehiscing by a small stoma situated at the apex of a definite umbo (which may be wanting); sterile base occupying the stem-like base, prominent, cells large, ferruginous, often tinged with purple; diaphragm absent.

Gleba yellowish, becoming olivaceous; columella prominent, elliptical; capillitium threads deep chestnut brown, sparsely branched or simple, continuous, not pitted. Spores globose, 3·5-4 μ diam., apedicellate; epispore pallid olivaceous, finely and closely verrucose.

Habitat.—Solitary, in groups or caespitose on the ground, usually in vegetable debris on the forest floor.

Distribution.—Britain; Europe; North and South America; India; East and South Africa; Algeria; Australia; New Zealand.

New South Wales: *Lismore, Oct., 1912; *Lisarow, June, 1916; *National Park, July, 1916; *Malanganee, Aug., 1917; *Comboyne, Sept., 1918.

Tasmania: *Hobart, F. R. Zeitz; Hobart, L. Rodway, Herb. No. 1413 (Type collection of *L. tasmanicum*).

New Zealand: **Weraroa, Jan., 1920; **Raurimu, Jan., 1920, E. H. Atkinson; **Whakatikei, June, 1923, J. C. Neill; **Orepuki, Nov., 1924, J. C. Neill.

The peculiar pointed verrucae of the exoperidium, which fall away and leave the endoperidium reticulate on account of the persistent smaller warts and

granules, form the chief character of this species. It is separated from *L. piriforme*, which otherwise it closely resembles, by this character, and by the spores, which are more strongly verrucose; then too, the sterile base is usually more deeply coloured, whereas it is usually pallid in *L. piriforme*. The spores are usually stated to be smooth, but this is an error, for all the collections listed above show these same verrucose spores.

The writer has examined type material of "*L. tasmanicum*," kindly donated by Mr. L. Rodway, and cannot see that it differs in any particular from *L. perlatum*. The verrucae are not so clearly defined as in the typical specimens, but this is not peculiar to *L. tasmanicum*, for several of the collections listed above possess small and poorly defined verrucae.

6. LYCOPERDON STELLATUM Cooke and Massee. Plate xlvii, fig. 12.

Grev., xv, 1887, p. 97.

Peridium depressed-globose, 2-3 cm. diam., with a small rooting base; exoperidium of stout, thick, connivent, pallid spines which fall away in small groups, but may persist towards base; endoperidium bay brown, or cream, smooth, save at the base where the exoperidium is partially persistent, membranous, dehiscing by a small, plane, torn, apical stoma; sterile base occupying the lower third of the peridium, ferruginous, cells minute, scarcely visible unless magnified; diaphragm absent.

Gleba ferruginous; columella absent; capillitium threads olivaceous, sparingly branched, continuous, thin walled, not pitted, about the diameter of the spores. Spores globose, 3·8-4·5 μ, apedicellate; epispore olivaceous, finely and closely verruculose.

Habitat.—Solitary on the ground.

Distribution.—Australia.

South Australia.—Israelite Bay, Type, in Herb. Kew; *Encounter Bay, Jan., 1925.

The peculiar nature of the exoperidium and small cells of the sterile base are the characters of the species.

Lloyd (1905, *a*) places it in his "*cruciatum*" section, but it differs from *L. candidum* (= *L. cruciatum*) in a most important character, namely, the absence of a diaphragm. The figure given by Massee (1887) is not characteristic, in that the spines are made much too coarse, and the sterile base is shown to be compact.

7. LYCOPERDON NITIDUM Lloyd. Plate xlvii, fig. 13.

Mycological Notes, 1924, p. 1305.

Peridium depressed globose, irregular, 2-4 cm. diam., umber, almost black, crenulate below, with a minute rooting base; exoperidium furfuraceous, flaking away irregularly, almost black; endoperidium papyraceous, umber, polished, dehiscing by a minute, plane, torn apical stoma; sterile base olivaceous, occupying the lower third of the peridium, cells minute, scarcely visible unless magnified; diaphragm absent.

Gleba olive-umber; columella absent; capillitium threads simple or sparingly branched, flaccid, olive, thin walled, pitted, continuous. Spores globose or subglobose, apiculate, 3·5-4·5 μ diam.; epispore olivaceous, delicately verruculose.

Habitat.—On the ground.

Distribution.—Australia.

South Australia: *Clare, Aug., 1922, Type collection.

This species is characterized by the depressed-globose form, minutely furfuraceous exoperidium, the thin and polished umber brown endoperidium, scanty, minutely cellular sterile base and pitted capillitium.

Lloyd states that there is no sterile base, but this is an error for this structure occupies quite one-third of the peridium.

8. Lycoperdon spadiceum Persoon. Plate xlvii, fig. 14.

Journ. Bot., ii, 1809, p. 20.—*L. Cookei* Mass., *Jour. Roy. Micr. Soc.*, 1887, p. 714.

Peridium 12-24 mm. diam., subglobose or more commonly shortly pyriform, with a long and slender rooting base, which may sometimes be branched; exoperidium furfuraceous, often in the form of mealy squamules, fugacious; endoperidium umber brown, papyraceous, smooth, dull, flaccid, sometimes covered with lime granules, dehiscing by an apical, torn, plane stoma; sterile base scanty, occupying the lower third of the peridium, or less, of small cells, umber; diaphragm absent.

Gleba olivaceous, becoming umber; columella absent; capillitium threads olivaceous, freely branched, continuous, not pitted, about the diameter of the spores. Spores globose, apiculate, 4-4·5 μ diam.; epispore olivaceous, minutely but distinctly verruculose.

Habitat.—Solitary on the ground.

Distribution.—Britain; Europe; Australia; New Zealand.

South Australia: *Mt. Lofty, June, 1921; July, 1922 (Det. Lloyd No. 851 as *L. pusillum*); *Big Swamp, west of Pt. Lincoln, May, 1923; *Beaumont, June, 1924 (2 collections); *Morphett Vale, Apl., 1925; *Kinchina, July, 1923; *Morialta, May, 1925; *F. R. Zeitz (3 collections).

Victoria: *Ararat, E. J. Semmens.

New Zealand: **Ashburton, Aug., 1925, J. C. Neill; **Kelburn, July, 1925.

Characterized by the small, sub-pyriform shape, furfuraceous exoperidium and scanty, small-celled, sterile base. The capillitium is freely branched, the plant differing in this respect from descriptions of the European form; but in other particulars it appears to be identical, even to the incrustation of lime granules on the exoperidium of occasional plants.

It closely resembles large forms of *L. pusillum*, but is separated readily on account of the presence of the cellular sterile base; and small forms of *L. polymorphum*, but the compact sterile base of the latter serves as a ready means of differentiation.

The New Zealand form collected at Kelburn possesses a more strongly developed exoperidium than is usual with this species; but in all other respects it is identical.

9. Lycoperdon polymorphum Vittadini. Plate xlviii, fig. 15.

Mon. Lyc., 1842, p. 39.—*L. coloratum* Peck, *N.Y. Nat. Hist. Mus. 29th Rept.*, 1878, p. 29.—*L. furfuraceum* Schaeff. ex de Toni in Sacc. *Syll. Fung.*, vii, 1888, 110.—*L. cepaeforme* (Bull.) Mass., *Journ. Roy. Micr. Soc.*, 1887, p. 722.—*L. hungaricum* Hollos, *Mathem. Term.*, xix, 1901, p. 1.—*L. nigrum* Lloyd, *Lyc. Aus.*, 1905, p. 30.

Peridium up to 6 cm. diam., yellow, becoming brown, depressed globose or more frequently pyriform, with or without a stem-like base which, when present, is often crenulate; exoperidium of minute spines or verrucae, often furfuraceous, fugacious; endoperidium membranous, often smooth and polished, dehiscing by a

small, torn, plane, apical stoma; sterile base compact, of the same interwoven hyphae as the gleba, concolorous, frequently scanty; diaphragm absent.

Gleba yellowish, becoming olivaceous, columella absent; capillitium threads pallid olive, thin walled, branched, continuous, about the diameter of the spores. Spores globose, 4·5-5·5 μ diam., apiculate; epispore tinted, closely and finely verruculose.

Habitat.—Solitary or in small groups on the ground.

Distribution.—Britain; Europe; North America; Algeria; South Africa; Australia; New Zealand.

New South Wales: *Milson Island, Hawkesbury River, Nov., 1914 (Det. Lloyd No. 86 as *L. cepaeforme* approaching *L. pusillum*); *Coolamon, May, 1918; *Bibbenluke, Mar., 1913; *Berrima, July, 1919.

South Australia: *Mt. Lofty, Apl., 1917; June, 1923; *Flinders Range, Aug., 1922; *Adelaide, F. R. Zeitz; *Ooldea, Aug., 1922; *Kinchina, July, 1923.

New Zealand: **Weraroa, Oct., 1919, E. H. Atkinson (Det. Lloyd as *L. cepaeforme*).

The species is characterized by the nature of the sterile base, which is either of a compact mycelial tissue similar in structure to the gleba, or of cells so minute as to be seen only when considerably magnified.

Frequently the sterile base is scanty, when plants approach *L. pusillum*; to this form the name *L. cepaeforme* has been applied, but it is impracticable to maintain, for in the same collection there may be present forms with either scanty or well developed sterile bases.

The spores are usually stated to be smooth, but they are closely and finely verruculose under the oil immersion.

The species is common in Australia, but has been collected but once in New Zealand.

10. Lycoperdon pusillum Persoon. Plate xlviii, fig. 16.

Jour. Bot., ii, 1809, p. 17.—*Bovista pusilla* Pers., *Syn. Meth. Fung.*, 1801, p. 138. —*Lycoperdon pusillum* (Batsch) Fries, *Syst. Myc.*, iii, 1829, p. 33.—*L. dermoxanthum* Vitt., *Mon. Lyc.*, 1842, p. 34.—*Bovista dermoxantha* (Vitt.) de Toni in Sacc. *Syll. Fung.*, vii, 1888, p. 100.—*B. pusilla* (Fr.) de Toni; Mass. in *Jour. Roy. Micr. Soc.*, 1887, p. 722.—*Lycoperdon mundulum* Kalchbr., *Grev.*, ix, 1880, p. 3.—*Bovista mundula* (Kalchbr.) de Toni, in Sacc. *Syll. Fung.*, vii, 1888, p. 98.—*Lycoperdon pseudopusillum* Hollos, *Noev. Koezl.*, ii, 1903, p. 75.—*L. semi-immersum* Lloyd, *Myc. Notes*, 1924, p. 1306.

Peridium up to 20 mm. diam., globose or suglobose, yellowish, becoming brown, with a strong basal rooting strand; exoperidium covered with minute, fugacious, mealy squamules or flattened verrucae, fugacious; endoperidium membranous, smooth, shining, flaccid, dehiscing by a small, irregular, plane apical stoma; sterile base absent.

Gleba yellowish, becoming brown; columella absent; capillitium threads olive, continuous, freely branched, pitted. Spores globose, 3·7-5 μ diam., apiculate; epispore olive, finely but distinctly verruculose.

Habitat.—Scattered or in small groups on the ground, often in cultivated areas.

Distribution.—Britain; Europe; North America; China; East and South Africa; Ceylon; Australia; New Zealand.

New South Wales: *Merebine, Oct., 1918; *Forbes, Aug., 1915; *Milson Island, Hawkesbury River, Mar., 1915; Feb., 1916; *Wagga, July, 1914 (Det. Lloyd No. 88

as *L. cepaeforme*); *Narrabri, Nov., 1916; *Baan Baa, Jan., 1917; *Narrabeen, Mar., 1916; *Blue Mts., May, 1914; *Orange, Oct., 1914.

South Australia: *Overland Corner, July, 1921; *Adelaide, July, 1914 (2 collections); *F. R. Zeitz (2 collections); *Kinchina, July, 1925; *Ooldea, Aug., 1922 (Det. Lloyd as type of *L. semi-immersum*).

New Zealand: **Ashburton, Jan., 1925; May, 1925, J. C. Neill; **Roxburgh, May, 1925, J. C. Neill.

This is a small plant with a subglobose peridium, and small but strongly developed rooting base. It is characterized by the absence of a sterile base, flaccid, shining endoperidium and freely branched capillitium. It is separated from small forms of *L. polymorphum* and *L. spadiceum* principally by the absence of a sterile base.

The species is the most variable of this most variable genus; the spores vary considerably in size and degree of roughness; the capillitium may range from sparsely branched to freely branched; the size of the peridium from 5 mm. to 20 mm. or more. Needless to say most of these conditions have been named, but it is not practicable to maintain them owing to the difficulty of delimiting each.

The writer has examined type-collection material of *L. semi-immersum* Lloyd and finds that it agrees in all particulars with *L. pusillum*. It was stated to be growing partially buried in sand, and Lloyd apparently has made this the main character of the species, for although he states that the spores are larger, they were found on examination to be exactly the same size as those of *L. pusillum*.

That these particular plants were partially buried in sand was but an accidental circumstance, and cannot be considered to be of specific import.

One form, from Hawkesbury River, has distinctly obovate spores.

11. Lycoperdon glabrescens Berkeley. Plate xlviii, fig. 17.

Fl. Tas., ii, 1860, p. 226.—*Bovistella glabrescens* (Berk.) Lloyd, *Lyc. Aus.*, 1905, p. 28.—*B. australiana* Lloyd, *l.c.*—*B. rosea* Lloyd, *Myc. Notes*, 1906, p. 248. Nomen nudum.

Peridium up to 5 cm. diam., bay brown, depressed globose or subglobose, often pyriform, tapering into a well developed stem-like base; exoperidium of small warts, larger towards the apex, fugacious; endoperidium bay brown, smooth, membranous, dehiscing by a small, erumpent, apical, torn stoma; sterile base well developed, cells small, often tinged with purple, occupying the stem-like base; diaphragm absent.

Gleba dark olivaceous, often purplish; columella wanting; capillitium threads freely branched, deeply coloured, about the diameter of the spores, pitted, continuous. Spores globose, 4-5 μ diam., pedicels tinted, acuminate; epispore olivaceous, minutely verruculose.

Habitat.—On the ground in groups, usually in pastures.

Distribution.—Australia; Tasmania; New Zealand.

New South Wales: *Milson Island, Hawkesbury River, Nov., 1914; *Sydney, Jan., 1915; June, 1916; *Mosman, Apl., 1915; *Manly, Apl., 1915 (Det. Lloyd No. 94 as *Bovistella australiana*); *Murwillumbah, Apl., 1916.

South Australia: *Mt. Dutton Bay, May, 1923; *Monarto South, July, 1922.

Victoria: Grantville, J. T. Paul, Herb. Vic. Dept. Agr. (Det. Lloyd as *Bovistella australiana*).

New Zealand: *No locality, J. B. Cleland; **Ashburton, Aug., 1925, J. C. Neill; D. W. McKenzie.

The members of the pedicellate-spored section of the genus are all—with one exception, *L. Gunnii*—closely related, and are separated mainly on the nature of the exoperidium.

In *L. glabrescens* the sterile base is prominent, but of small cells, a character tending to separate it from *L. asperum*, in which the sterile base is scanty and frequently almost wanting. The minutely verruculose exoperidium separates it from *L. scabrum*.

Lloyd has named this species *Bovistella australiana*, but as the species is well covered by the descriptions of *L. glabrescens* his specific name is considered superfluous. Lloyd's *Bovistella rosea* is considered a synonym, for it agrees in all particulars save the alleged rose (!) colour of the gleba.

12. LYCOPERDON SCABRUM (Lloyd) G. H. Cunn. Plate xlviii, figs. 18-19.

Bovistella scabra Lloyd, *Myc. Notes*, 1906, p. 282.—*B. nigrica* Lloyd, *Myc. Notes*, 1922, p. 1115.—*L. scabrum* G. H. Cunn., *Trans. N.Z. Inst.*, lvii, 1926, 199.

Peridium up to 3 cm. diam., depressed globose or pyriform, umber, with a well developed rooting base; exoperidium of long black or brown spines, 1-3 mm. long, free at the base, frequently connivent at the apices, fugacious; endoperidium umber, at length smooth, shining, membranous, dehiscing by an erumpent, torn, toothed apical stoma; sterile base occupying the lower third of the peridium, of small cells, concolorous; diaphragm absent.

Gleba olivaceous, becoming umber; columella absent; capillitium threads olivaceous, freely branched, pitted, continuous. Spores globose, 4-5 μ diam., pedicels acuminate, tinted; epispore olive, finely and evenly verruculose.

Habitat.—Solitary on the ground.

Distribution.—Australia; New Zealand.

South Australia: *Pearson Island, Gt. Australian Bight, Jan., 1923.

Victoria: Grantville, J. T. Paul (Det. Lloyd as *Bovistella scabra*), Herb. Vic. Dept. Agr.

New Zealand: **Weraroa, Oct., 1919, E. H. Atkinson; **Weraroa, Nov., 1919 (Type of *Bovistella nigrica*).

Characterized by the long spines of the exoperidium, and the well developed sterile base. It closely resembles the preceding, being separated on account of the cruciate spines of the exoperidium.

Lloyd's *Bovistella nigrica* is identical in all respects, save that of colour, with the specimens he has determined as *Bovistella scabra*; but the colour of the plants is not constant, for in one New Zealand collection are both brown (*B. scabra*) and dark brown (*B. nigrica*) specimens.

13. LYCOPERDON ASPERUM (Lev.) de Toni. Plate xlviii, figs. 20-21.

Sacc. *Syll. Fung.*, vii, 1888, p. 119.—*Bovista aspera* Lev., *Ann. Sci. Nat.*, ser. 3, v, 1846, p. 162.—*Lycoperdon australe* Berk., *Fl. Tas.*, ii, 1860, p. 266.—*Bovistella aspera* (Lev.) Lloyd, *Lyc. Aus.*, 1905, p. 29.

Peridium up to 3 cm. diam., bay brown, globose, depressed globose or pyriform, with a well developed rooting base; exoperidium of short, stout, pallid spines often convergent in fours at the apex, fugacious; endoperidium membranous, bay brown, smooth, dehiscing by a small, irregularly torn, plane apical stoma; sterile base scantily developed, of small cells; diaphragm absent.

Gleba pallid olivaceous; columella wanting; capillitium threads olivaceous, branched, pitted, continuous. Spores globose, 4-4·5 μ diam., pedicels acuminate, tinted; epispore pallid olive, minutely verruculose.

Habitat.—Solitary or in small groups on the ground.

Distribution.—Chile; New Guinea; South Africa; Australia; Tasmania.

New South Wales: *Blue Mts., Nov., 1914; *Sydney, Apl., 1915; *Milson Island, Hawkesbury River, Oct., 1914; *Penshurst, Feb., 1908 (Det. Lloyd as *Bovistella aspera*); *Macquarie Pass, Aug., 1917.

Victoria: *Ararat, May, 1918, E. J. Semmens; Dimboola, F. M. Reader (Herb. Vict. Dept. Agr.).

South Australia: *Adelaide, F. R. Zeitz; *Pearson Island, Gt. Australian Bight, Jan., 1923; *Mt. Lofty, July, 1922; *Monarto South, Sept., 1920 (Det. Lloyd as *Bovistella aspera*); *Mt. Compass, Aug., 1921.

Tasmania: Hobart, L. Rodway, No. 1417; Hobart, L. Rodway, No. 1418 (Det. Lloyd as *Bovistella australiana*).

Characterized by the (usually) minute sterile base and especially by the nature of the exoperidium, which is of short, stout, pallid spines often converging in fours at the apices. Plants vary considerably in the degree of the roughness of the spores, and depth of the colour of the capillitium, doubtless owing to many being collected before they were properly matured.

L. australe is by Lloyd considered a synonym of *L. pusillum*, but as the description calls for a plant with a rough exoperidium and pedicellate spores, it is by the writer considered a synonym of this species.

14. LYCOPERDON GUNNII Berkeley. Plate xlviii, fig. 22.

Fl. Tas., ii, 1860, p. 265.—*Bovistella Gunnii* (Berk.) Lloyd, *Lyc. Aus.*, 1905, p. 29.

Peridium 1-2 cm. diam., globose or subglobose, bay brown or yellowish-brown, with a small rooting base; exoperidium at first covered with minute warts, or tomentose, becoming flocculent and areolate when old; endoperidium bay brown, or yellowish, dehiscing by a small, irregularly torn, plane, apical stoma; sterile base absent, or seldom scantily developed.

Gleba yellowish, becoming olivaceous; columella absent; capillitium threads pallid olivaceous, or lemon yellow, thin walled, sparsely branched, continuous, pitted. Spores globose, 4-5 μ diam., pedicels tinted, acuminate; epispore tinted yellow, finely verruculose.

Habitat.—Solitary or in small groups on the ground.

Distribution.—Australia; Tasmania.

New South Wales: *Sydney, Apl., 1915 (Det. Lloyd No. 95 as *Bovistella Gunnii*); *Milson Island, Hawkesbury River, Nov., 1914; *Blayney, Dec., 1917; *Mummulgum, Dec., 1916.

Victoria: *Ararat, May, 1917, E. J. Semmens.

South Australia: *Big Swamp, west of Pt. Lincoln.

Tasmania: Hobart, L. Rodway, No. 1415.

A small subglobose plant with a poorly developed rooting base, the sterile base usually being absent. The yellowish nature of the gleba, capillitium and spores, sparingly branched, flaccid capillitium, small size of the peridium, and the furfuraceous nature of the exoperidium, are the specific characters of the species.

Doubtful or Excluded Species.

The following have been recorded in literature as having been collected in Australia or New Zealand. Most of the records are in Massee's Monograph (1887), in which he appears to have described as new every specimen in the Kew

Herbarium not placed in the cover of some well-known European species. Some idea of the quality of this work may be obtained from the fact that of the nineteen species recorded therein as having been collected in Australasia, four are, in the writer's opinion, correctly named. Needless to say, all species from Australasia recorded therein as new, are viewed with grave suspicion.

Cooke has compiled these, together with certain others, in his Handbook (1892); in this publication there are listed twenty-five species, of which five are correctly named.

a. *Lycoperdon australe* Berk. = *L. asperum* (Lev.) de Toni.
b. *L. Bovista* Fr. = *Calvatia gigantea* (Pers.) G. H. Cunn.
c. *L. bovistoides* Cke. et Mass. = *Bovistella bovistoides* (Cke. et Mass.) Lloyd.
d. *L. cepaeforme* (Bull.) Mass. = *L. polymorphum* Vitt.
e. *L. caelatum* (Bull.) Fr. = *Calvatia caelata* (Bull.) Morg.
f. *L. Colensoi* Cke. et Mass. = *L. perlatum* Pers.
g. *L. Cookei* Mass. = *L. spadiceum* Pers.
h. *L. coprophilum* Mass. = *Bovistella coprophila* (Mass.) G. H. Cunn.

In Dr. Cleland's possession are specimens which are well covered by the description of "L. coprophilum". The plants belong to the genus *Bovistella*, possessing the capillitium and rooting base of this genus.

i. *L. cruciatum* Rostk. This, a synonym of *L. candidum* Bon., has been recorded by Lloyd as occurring in Australia, but the plants so labelled in the possession of Dr. Cleland (determined as such by Lloyd) are typically *L. depressum* Bon.
j. *L. dermoxanthum* Vitt. = *L. pusillum* Pers.
k. *L. Fontanesii* D. et M. = *Calvatia caelata* (Bull.) Morg.
l. *L. giganteum* Batsch = *Calvatia gigantea* (Pers.) G. H. Cunn.
m. *L. gemmatum* Batsch = *L. perlatum* Pers.
n. *L. lilacinum* (B. et M.) Mass. = *Calvatia lilacina* (B. et M.) Lloyd.
o. *L. mundulum* Kalchbr. = *L. pusillum* Pers.
p. *L. microspermum* Berk. = *L. pusillum* Pers.
q. *L. natalense* Cke. et Mass. = *L. depressum* Bon.
r. *L. nigrum* Lloyd = *L. polymorphum* Vitt.
s. *L. novae-zelandiae* Lev. = *Calvatia lilacina* (B. et M.) Lloyd.
t. *L. pseudopusillum* Hollos = *L. pusillum* Pers.
u. *L. purpuraceum* Berk. (= *L. purpureum*). A misdetermination by Lloyd for *L. subincarnatum* Peck.
v. *L. retis* Lloyd, *Myc. Notes*, 1923, p. 1176.

"About an inch in diameter with a slender tap root. Strongly reticulate (when dry at least) from what reason I do not know. Sterile base none. Gleba grey olive pale. Exoperidium smooth when old, but evidently (from remains) furfuraceous when young. Endoperidium thin, not dehiscing in any of these specimens. Capillitium long, subhyaline, scantily branched, hollow threads 5-6 μ thick, not septate as far as I could find. Spores globose, 4-5 μ, coloured, smooth.

"Victoria: E. J. Semmens.

"It grows in pastures and may be a *Calvatia*. The curious reticulations suggested at first that it was a *Clathrus* egg. Its relations are evidently close to the 'pratense' section, from which it differs in absence of a sterile base".

As Lloyd doubts the genus he should not have described the species from such faulty material.

w. *L. reticulatum* Berk. = *L. pusillum* Pers. probably.

x. *L. Sinclairii* Berk. = *Calvatia caelata* (Bull.) Morg.

y. *L. substellatum* B. et C. Probably a misdetermination of *L. subincarnatum* Peck, for Massee recorded it only from Cuba.

z. *L. tasmanicum* Mass. = *L. perlatum* Pers.

aa. *L. tephrum* Berk. = *L. subincarnatum* Peck.

bb. *L. violascens* Cke. et Mass. = *Calvatia lilacina* (B. et M.) Lloyd.

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Index to Species and Synonyms.

EXPLANATION OF PLATES XLVI–XLVIII.

Plate xlvi.

Fig. 1. *Lycoperdon depressum*, × 5/9. Showing variation in the nature of the exoperidium.

Fig. 2. *L. depressum*, × 5/6. Showing (top) the crenulate, well-developed sterile base, and (bottom) the manner of dehiscence.

Fig. 3. *L. depressum*, × 5/6. Showing the gleba, sterile base and prominent diaphragm.

Fig. 4. *L. subincarnatum*, × 5/6. Australian plants with adhering exoperidium.

Fig. 5. *L. subincarnatum*, × 3. Enlarged to show the pitted endoperidium. American plant.

Fig. 6. *L. compactum*, × 5/6. Showing caespitose habit and ligneous habitat.

Fig. 7. *L. compactum*, × 5/3. Note the reticulate endoperidium, long black spines of the exoperidium, and scanty sterile base.

Plate xlvii.

Fig. 8. *L. piriforme*, × 5/12. Showing the varied shapes of the plants.

Fig. 9. *L. piriforme*, × 5/6. Note the almost furfuraceous exoperidium.

Fig. 10. *L. perlatum*, × 5/12. Australian and New Zealand plants showing the varied shapes of the plants; note the caespitose habit.

Fig. 11. *L. perlatum*, × 3. European plant showing the peculiar verrucae which characterize the species. These verrucae are not so strongly developed in Australasian forms.

Fig. 12. *L. stellatum*, × 5/6. Basal photo showing the rooting base and especially the remnants of the warted exoperidium.

Fig. 13. *L. nitidum*, × 5/6. Immature plant with adhering exoperidium, above.

Fig. 14. *L. spadiceum*, × 5/6. Sterile base shown in the sectioned plant. Note the furfuraceous exoperidium, which is more strongly developed than is usual (New Zealand plants).

Plate xlviii.

Fig. 15. *L. polymorphum*, × 5/6. Showing the diverse shapes.

Fig. 16. *L. pusillum*, × 5/6.

Fig. 17. *L. glabrescens*, × 5/9.

Fig. 18. *L. scabrum* × 5/9. Showing the well-developed rooting base and the prominent torn stoma.

Fig. 19. *L. scabrum*, × 3. Note the scabrous exoperidium.

Fig. 20. *L. asperum*, × 5/6.

Fig. 21. *L. asperum*, × 3. Showing the scabrous exoperidium.

Fig. 22. *L. Gunnii*, × 5/6.

Figures 2 and 7 from photographs by H. Drake, the remainder by the writer.

A RECLASSIFICATION OF AUSTRALIAN ROBBERFLIES OF THE *CERDISTUS-NEOITAMUS* COMPLEX (DIPTERA—ASILIDAE).

By G. H. HARDY, Walter and Eliza Hall Fellow in Economic Biology, Queensland University, Brisbane.

(Seven Text-figures.)

[Read 24th November, 1926.]

For Australian Asilids, as also those of elsewhere, generic names are being used that were founded upon European species and without true regard to relationships. White pointed out these shortcomings very effectively when he made the first effort to put the more obscure Asilinae on a better basis. I am indebted to Professor M. Bezzi who has kindly supplied me with a number of Asilids representing the typical forms of their genera, thus enabling me to develop White's suggestions for improvement. White did not examine all the genera allied to those he dealt with and that may be related to Australian material; one of these, *Paritamus*, he evidently overlooked, this being even more typically Australian in appearance, if not in relationship, than either *Neoitamus* or *Cerdistus*. I have not seen *Glaphyropyga* under which Schiner described a species, the typical form being from Brazil.

Many authors regard *Asilus* as being a genus that should incorporate others hitherto not very well defined and, therefore, would relegate such to a position of subgeneric value. There seems to be no difficulty, however, in dividing *Asilus*, used in that wide sense, into two very clearly defined groups. The scheme here proposed certainly holds well for all the Australian material yet known and, as far as I can gather, the same seems true, if suitable modifications are incorporated, for European and North American species.

In *Asilus* and its allies the dorsal surface of the eighth abdominal segment is subequal to the seventh, convex above and flat below, and its appearance is that of a normal segment even when it is bare, black and shining. In *Cerdistus* and its allies, with which the present paper deals, the eighth abdominal segment of the female has an appearance quite distinct from that of *Asilus*. Typically it is compressed, the ventral half invariably being so. On those two Australian genera, *Pararatus* and *Blepharotes*, which strictly do not belong to either of these groups, it approaches the same form, but the ventral half of the eighth abdominal segment is not so closely amalgamated with the upper half. The upper half is but slightly compressed, showing a convex dorsal surface, and the ventral half is not quite so compressed as in *Cerdistus*, but the best distinguishing feature is to be found in the structure of the lamella. In *Cerdistus*, as also in *Asilus*, this appendage is cylindrical, but in *Pararatus* and *Blepharotes* it is quite differently constructed, being broad, flat, and somewhat arched. I have seen the organ in use on a species of *Asilus* that was ovipositing on a leaf, and it acted as a sensory organ, feeling for a vacant spot amongst a mass of eggs already deposited. The final cluster of eggs represented a mass of orderly rows, although they were not necessarily deposited in sequence along these rows, gaps being left and filled later.

The lamella on *Pararatus* and *Blepharotes* could scarcely be used in this manner, but appears to form a guide by means of which the issuing eggs are kept in a straight course.

In *Cerdistus* and allies, the eighth abdominal segment, the so-called ovipositor, is much longer than the seventh, or, if but barely so, it is entirely compressed. This ovipositor is evidently a highly organized modification arising from the more primitive type, as represented by the eighth segment on *Asilus*, and is due to a need for an extension of the apex of the abdomen. This reaches a maximum, perhaps, in *C. constrictus*, n. sp., where it is almost as long as the rest of the abdomen. Another form of extreme adaptation is taken by the species grouped under *Neoitamus*, on which there is a more or less marked tendency for the ovipositor to incorporate the sixth and seventh segments as well as the eighth. In this latter case the sixth and seventh segments are never compressed ventrally, the ventral surface may be small and elongate, but never linear. Genera such as *Antipalus*, which have distinctive forms of ovipositor, do not come within the present scope of study. *Philonicus*, with spines on the ovipositor, is included in the key as it is somewhat analogous to the new genus *Neocerdistus* but, however, in no way related to it.

White considered that the robberflies here dealt with are in some cases fairly typical of *Neoitamus*, but show every gradation between it and *Cerdistus*, *Machimus*, *Epitriptus* and *Stilpnogaster*, at the same time not agreeing with any of them. In consequence he used *Neoitamus* and suggested names for two other divisions, but in the present study it has been found possible to eliminate two of the five older genera mentioned by White, leaving a total number of six names in the *Cerdistus-Neoitamus* complex and the manner of doing this is indicated in the following key:

Key to the genera allied to the Cerdistus-Neoitamus *complex.*

1. Ovipositor without a lamella 2
   Ovipositor with a lamella 3
2. Ovipositor with subapical spines placed dorsally .... *Philonicus*
   Ovipositor without such spines, but with a pair of small processes placed apically .... *Neocerdistus*, n. gen.
3. Lamella wedged in; that is, the ovipositor extends some distance above, below, or both above and below the lamella, thus limiting the range of its movements .... *Dysmachus*, *Machimus*, *Eutolmus*
   Lamella free 4
4. Anterior femora with well developed bristles on the anterior dorsal or posterior surfaces .... *Heligmoneura*, *Tolmerus*, *Epitriptus*
   Anterior femora without bristles on these surfaces and rarely so on the ventral surface .... *Cerdistus*, *Stilpnogaster*, *Neoitamus*, *Paritamus*, *Trichoitamus* and *Rhabdotoitamus*.

Note.—Exception may be made to the grouping of *Eutolmus* with *Machimus* and *Dysmachus*, but if this is not acceptable, owing to the movements of the lamella being less limited than I suspect it to be (admittedly a contentious point), then the genus would fall to the first half of the third couplet, joining *Tolmerus* and *Epitriptus*. My only female specimen of *Heligmoneura* is without a lamella, but this appears to have been broken off and in any case the genus is not of the *Cerdistus-Neoitamus* complex.

The Australian material falls into two of these groups, *Neocerdistus* and the last, in which six names are given. It seems advisable to collocate *Cerdistus*, *Stilpnogaster*, *Neoitamus*, *Paritamus*, *Trichoitamus* and *Rhabdotoitamus* as representing one genus, seeking characters that will arrange these anew into groups

of subgeneric value. Obviously this cannot be accomplished on the study of Australian material alone, but it becomes necessary to substitute *Cerdistus* for *Neoitamus* owing to its earlier publication and in accordance with the scheme of classification here proposed. The generic name *Cerdistus* thus becomes a basis whereon further developments may be made, and this group divides into four subgenera in accordance with the following key.

Provisional key to the subgenera of Cerdistus.

1. Sixth and seventh abdominal segments bare, shining and more or less compressed .... *Neoitamus*
   Seventh abdominal segment bare, shining and more or less compressed .. *Subgen.* (?)
   Sixth and seventh abdominal segments normal, covered with tomentum similar to that on the anterior ones 2
2. Male genitalia with an apical projection on the upper forceps .... *Cerdistus* (including *Paritamus*, *Trichoitamus*, *Rhabdotoitamus*)
   Male genitalia simple, at most with a subapical constriction of the upper forceps .... *Stilpnogaster*

The recognizable described Australian species fall naturally into these subgenera, as is shown in the following list. Although the divisions here proposed may be considered artificial, they have the great advantage of keeping together those forms that are obviously closely allied, whilst any division based upon colour, as proposed by White, would separate some of them.

Neoitamus
- *setosus* Hardy.
- *rusticanoides*, n. sp.
- *fulvipubescens* Macquart.

Subgen. ?
- *flavicinctus* White.

Cerdistus.
- *maricus* Walker.
- *vittipes* Macquart.
- *fraternus* Macquart.
- *lautus* White.

Cerdistus contd.
- *gibbonsi* Ricardo.
- *rudis* Walker.

Stilpnogaster
- *armatus* Macquart.
- *claripes* White.
- *neoclaripes* Hardy.
- *constrictus*, n. sp.
- *conformis*, n. sp.
- *margitis* Walker.
- *laticornis* Macquart.
- *maculatoides* Hardy.

For the time being it seems advisable to retain *flavicinctus*, for which there appears to be no subgeneric name available, in *Neoitamus*, especially as this is the only species definitely known to me with its type of ovipositor; presumably, however, *N. hyalinipennis* Ricardo (*nec* White) conforms to the same. All the unnamed Australian species known to me also fall into these groups. *N. maculatus* White is only known from one sex and therefore cannot be included in the above list.

Distribution of Tasmanian species of Neocerdistus and Cerdistus. There are ten species of these flies recorded from Tasmania, and White described most of them. A complete list is given below with synonymy. Four species, *flavicinctus*, *fraternus*, *mistipes* and *laticornis*, have not been found on the mainland; the others occur as far as half way up the eastern coast of Australia, many reaching Brisbane which seems to mark the northern limit. As far as yet known none of them reach South Australia, the dipterous fauna of which State seems allied to that of Perth, Western Australia.

Neocerdistus, n. gen.
  acutangularis Macquart (*dubitus* White, Hardy).

Cerdistus Loew.
(*Neoitamus*) *flavicinctus* White, Hardy.
(*Cerdistus*) *vittipes* Macquart, Hardy (*cognatus* Macquart, *brunneus* White).
fraternus Macquart, Hardy (*luctificus* Walker, *vulgatus* White).
gibbonsi Ricardo (*hyalinipennis* White, *nec* Ricardo).
rudis Walker, White.
(*Stilpnogaster*) *armatus* Macquart, Hardy.
margitis Walker, Hardy (*varifemoratus* Macquart, *caliginosus* White).
laticornis Macquart.
(——) *mistipes* Macquart (*graminis* White), not seen by me.

Notes on some types in the British Museum.

I am greatly indebted to Mr. E. Brunetti who has compared some twelve or more sketches of male genitalia with the types in the British Museum and of these the following species have been commented upon.

R. rusticanus White. Mr. Brunetti remarks that my "figure does not agree well". He states that the forceps are shorter and the end is obtuse, the lamella prominent, the lower forceps much less curved. The depression that gives a bulge at the base of the upper forceps in my drawing is absent. The phrase "does not agree well" suggests that there was a resemblance and so it becomes possible to suppose that the apex of the upper forceps was turned inwards on the type and the depression on the upper forceps near the base may be a variable character, for it seems to serve no purpose. On the specimen I have drawn, the lower forceps are certainly distorted, for they expose a portion of the inner claspers that would normally be hidden. Unfortunately Mr. Brunetti did not make a sketch of the genitalia of the type, but, in view of his remarks, I am giving a new name to the form previously identified by me in collections as White's species and is described below as "*rusticanoides*".

N. gibbonsi Ricardo.—The remarks confirm the identification given below.

N. rudis Walker.—My identification from a Melbourne specimen is evidently correct.

N. rudis Ricardo from Sydney, is sketched by Mr. Brunetti with a very long lamella, but without the apical process which exists on all the specimens under the name in Australia. Perhaps the processes are curved inwards, a not very uncommon occurrence on specimens which have beeen killed before the chitin hardens.

N. rudis White.—The general plan agrees with Walker's type, but Mr. Brunetti doubts if the two forms are identical. It may be as well to state here that the difference according to my sketches, supplied for comparison, lay in the direction of the apical process, this being horizontal on White's species and directed downwards on Walker's.

N. claripes White confirms the recent identification referred to below.

N. australis Ricardo; "type in bad condition". My sketch of *N. claripes* White, and that drawn by Mr. Brunetti to represent *N. australis* Ricardo, are remarkably similar.

NEOCERDISTUS, n. gen.

The species described by White as *Neoitamus abditus* from Tasmania differs from species of *Cerdistus* as here understood, by not possessing a lamella at the apex of the ovipositor; it has instead a pair of conical processes. White drew attention to the unique character in the wing venation, the second posterior cell

being strongly constricted subapically; the genus can be readily recognized by this alone on both sexes.

When illustrating the ovipositor of the typical form, an error was made in the proportion of the minute apical processes, these being represented in the drawing as twice as long as they are on the type, whilst other specimens have them still shorter. A Queensland species has them more in accordance with the drawing, giving that apparent bifurcate appearance that may have been the kind referred to by Miss Ricardo when she alluded to the type of *A. obumbratus* Walker as "seems allied to *Cerdistus* but the ovipositor ends in a fork".

As far as yet known the species of this genus occur only during the late summer and autumn, whilst the lack of the style suggests that a habit or manner of oviposition differs from that of *Cerdistus*.

Type, *Neoitamus abditus* White (*acutangularis* Macquart). Tasmania.

NEOCERDISTUS ACUTANGULARIS Macquart.

Asilus acutangularis Macquart, *Dipt. Exot.* suppl. 2, 1847, 44.—*Neoitamus abditus* White, *Proc. Roy. Soc. Tasmania*, 1916, 178, fig. 29, and 1917, 93; Hardy, PROC. LINN. SOC. N.S.W., xlv, 1920, 190, figs. 1-3, and xlvi, 1921, 295.

Synonymy.—There is no species from Tasmania that fits Macquart's description so well as White's *N. abditus*, so there can be little doubt concerning the correctness of this synonymy.

Hab.—Tasmania, Victoria and New South Wales, February to April.

Genus CERDISTUS Loew.

Neoitamus of recent Australian authors.

It has already been pointed out that the generic name *Cerdistus* must be substituted for *Neoitamus*. Many of the species placed here have their nearest ally in *Paritamus* Verrall, a European genus that has not yet been defined. The priority of Verrall's name over the two proposed by White would be enough to commend itself as a substitute for at least one of them, but the Australian forms are regarded as constituting a complex in themselves and probably will ultimately prove divisible into several well defined groups to which two or more of the names already discussed will be applicable.

In a previous paper a key was given to the species then revised and it was based upon characters of both sexes. That key is extended and slightly amended so as to include the species revised below. The male may always be identified by referring to the drawings of the genitalia, but some difficulty will be experienced in identifying females, or in allying them with the males, so a second key is given, based upon the characters of the female only.

There are 57 specific names included under this genus and *Neocerdistus*; of these 21 are recognized as valid, most being applied to specimens in Australian collections. There are 16 names relegated to synonymy and 20 names are still outstanding. Probably about 6 will ultimately be found impossible to identify without their types becoming available for study, the remainder being diagnosed sufficiently, though often barely enough, for recognition when, as is the case with the Tasmanian forms, the fauna from their respective type localities becomes better known. There are now no outstanding species from Tasmania, and only a single specimen, a female, taken by Dr. A. Jefferis Turner at Cradle Mt., represents a new form in that State. The following is a full list of the outstanding names:

Macquart: *Asilus australis, exilis, filiferus, longiventris, nigrinus, rufocoxatus, rufometatarsus.*

Walker: *Asilus coedicus, mutilatus, obumbratus* (undoubtedly a *Neocerdistus*) and *villicatus.*

Schiner: *Glaphyropyga australasiae.*

Ricardo: *Cerdistus australis, Neoitamus hyalipennis.*

White: *Neoitamus divaricatus, Rhabdotoitamus lividus, volaticus, rusticanus.*

Dakin and Fordham: *Machimus forresti, Neoitamus cygnus.*

Key to the species of Cerdistus *based on both sexes.*

1. Upper forceps of the male genitalia with a terminal process 2
   Upper forceps without a terminal process 9
2. Male genitalia short and globular, the apical process rising above the centre of the posterior margin and more or less at right angles to it. Ovipositor short. Two supra- and three post-alar bristles .... *maricus* Walker
   Male genitalia elongate; if the apical process projects more or less at right angles to the posterior margin it rises below the centre of the upper forceps 3
3. The sixth and seventh segments of the female abdomen bare, shining and subcompressed 4
   Only the seventh segment of the female abdomen bare, shining and subcompressed .... *flavicinctus* White
   The sixth and seventh segments of the female abdomen normal 5
4. Male genitalia with a conspicuous swelling at the base of the upper forceps; supra- and post-alar bristles two each .... *rusticanoides*, n. sp.
   Without the swelling at the base of the upper forceps; one or two supra- and two post-alar bristles .... *fulvipubescens* Macquart
5. Dorsal and ventral surfaces of the upper forceps tapering sharply to the apex which is truncate; two supra- and one, rarely two, post-alar bristles .... *vittipes* Macquart
   Dorsal and ventral surfaces of the upper forceps more or less parallel; supra- and post-alar bristles two each 6
6. Apical process small, directed upwards and issuing from about the centre of the posterior border of the upper forceps 7
   Apical process issuing from the lower half of the upper forceps 8
7. Black species from Tasmania .... *fraternus* Macquart
   Brownish species from Victoria .... *lautus* White
8. Upper forceps appear to be deeply emarginate at the apical border so as to form two apparent processes. Ovipositor long .... *gibbonsi* Ricardo
   Apical process strongly developed, forming a continuation of the upper forceps, but a small dorsal hump marks the division between the two. Ovipositor short .... *rudis* Walker
9. Male genitalia with bristles 15
   Male genitalia without bristles 10
10. Anterior femora with a conspicuous row of ventral bristles. Ovipositor long. Two supra- and one, rarely two, post-alar bristles .... *armatus* Macquart
    Anterior femora without ventral bristles 11
11. Ovipositor compressed ventrally, but has a dorsal surface. Two supra-, one or two post-alar bristles .... *maculatoides* Hardy
    Ovipositor entirely compressed 12
12. Ovipositor short 13
    Ovipositor very long 14
13. Supra- and post-alar bristles one each; brown species .... *claripes* White; *neoclaripes* Hardy
    Two supra- and one post-alar bristles; a small black species from Tasmania .... *laticornis* Macquart
14. Ovipositor about the length of the third to seventh abdominal segments inclusive. Supra- and post-alar bristles two each .... *constrictus*, n. sp.
    Ovipositor a little less than the length of the fourth to seventh abdominal segments inclusive. Two supra-, one or two post-alar bristles .... *conformis*, n. sp.
15. Upper forceps of the male genitalia with a row of about ten slender dorsal bristles. Two supra-, one or two post-alar and two scutellar bristles. Sixth and seventh abdominal segments of female normal .... *margitis* Walker

Upper forceps of male genitalia with one long ventral bristle; lower forceps with a row of ventral bristles. Two or three supra-, three or four post-alar and four scutellar bristles. Sixth and seventh abdominal segments of female subcompressed and shining .... *setosus* Hardy

Key to the species of Cerdistus *based upon females only.*

1. Sixth and seventh abdominal segments bare, shining and subcompressed 2
   Only the seventh abdominal segment bare, shining and subcompressed ....
   .... *flavicinctus* White
   Sixth and seventh abdominal segments normal 4
2. Thorax with only one supra-alar bristle .... *rusticanoides*, n. sp.
   Thorax with at least two supra-alar bristles 3
3. Thorax with not more than two postalar bristles .... *fulvipubescens* Macquart
   Thorax with not less than three postalar bristles .... *setosus* Hardy
4. Anterior femora with strong ventral bristles .... *armatus* Macquart
   Anterior femora without ventral bristles 5
5. Thorax with two median stripes 6
   Thorax with one undivided broad median stripe 13
6. Ovipositor very long, as long as the three and a half anterior segments ....
   .... *conformis*, n. sp.
   Ovipositor much shorter than this 7
7. Wings with conspicuous spots; black species from Western Australia ....
   .... *maculatus* White
   Wings rarely with spots, but if so from the east-coast of Australia 8
8. Thorax with three postalar bristles .... *maricus* Walker
   Thorax with not more than two postalar bristles 9
9. Moustache entirely or predominantly white 10
   Moustache conspicuously mixed with black and white hairs 11
10. A black species .... *margitis* Walker
    A brown species .... *vittipes* Macquart
11. Tubercle covering nearly the whole of the face .... *rudis* Walker
    Tubercle covering only half the face 12
12. A black species from Tasmania .... *fraternus* Macquart
    A brown species from Victoria .... *lautus* White
13. Ovipositor short and subcompressed .... *maculatoides* Hardy
    Ovipositor entirely compressed 14
14. Ovipositor very long, at least as long as from fifth to seventh abdominal segments inclusive 15
    Ovipositor short 16
15. Ovipositor as long as from fifth to seventh abdominal segment inclusive ....
    .... *gibbonsi* Ricardo
    Ovipositor as long as from third to seventh abdominal segment inclusive ....
    .... *constrictus*, n. sp.
16. Small black species with dark legs. From Tasmania ...... *laticornis* Macquart
    Medium sized brownish species with light coloured legs ....
    .... *claripes* White. *neoclaripes* Hardy

CERDISTUS RUSTICANOIDES, n. sp. Text-fig. 1.

A brownish species. In the male the moustache is composed of white or yellow hairs with a few black ones above, in the female black with a few yellow ones below. Behind the eyes the row of bristles is missing on the male and restricted to a few black bristles on the female. The dorsal thoracic bristles are disposed on each side of the median line as follows: Two presutural, one supra-alar, one postalar and four or five weak dorsocentrals. The scutellum contains two weak yellow bristles and the meta- and hypo-pleurals are also yellow. The lateral abdominal bristles are yellow and weak on the male and, except on the first segment, are missing on the female. The genitalia on the male contain an apical process, well developed and directed more or less horizontally, arising from the lower half of the upper forceps at the base of which is a conspicuous swelling.

The sixth and seventh abdominal segments are bare of tomentum and shining; only the seventh is definitely subcompressed, but the specimen under examination has not these segments in very good condition. The bristles on the femora are reduced in number and are irregular in occurrence, but they indicate the rows usually traceable on the intermediate and posterior femora. The venation of the wings is normal, the intermediate cross-vein is situated at the centre of the discal cell and the first posterior cell is rather long. Length, 13-17 mm.

Hab.—Victoria: Ferntree Gully, two males and one female, collected by C. E. Cole, 24th November, 1918; in the National Museum. This species was previously labelled by me as *R. rusticanus* White.

CERDISTUS FULVIPUBESCENS Macquart. Text-fig. 2.

Asilus fulvipubescens Macquart, *Dipt. Exot.*, Suppl. 4, 1850, 92.

A brownish species. On the male the yellow-brown face has a small tubercle with a white moustache and on the female a few black hairs occur above the white. The reddish antennae may be stained with black at the apex; the brown front has a few black or yellow hairs. Palpi and proboscis black, the hair on the former and beard white. A row of yellow bristles behind the eyes on the male and about six black bristles on the female represent this row. The dorsal thoracic bristles are disposed on each side of the median line as follows: Two presutural, two supraalar, one or two postalar and four or five dorsocentrals, all black. Two scutellar, the meta- and hypopleural bristles are reddish. On the dorsum there are two median brown stripes and at the apex of these a short stripe that reaches to and is traceable on the scutellum. A brown lateral, interrupted stripe reaches from before the transverse suture to near the scutellum. The lateral abdominal bristles are yellow. The upper forceps of the male genitalia are rather long and slender, and terminate in a strong horizontally directed process. On the female the sixth and seventh abdominal segments are bare, black and subcompressed, and the ovipositor is rather long. Legs entirely yellowish except at the apices of tibiae and femora, which are black, and occasionally other parts of the legs are stained darker. Intermediate and posterior femora have their ventral bristles long and slender; on the anterior side four or five bristles occur, whilst on the posterior side they are restricted to one subapical bristle. The venation of the wings is normal, the intermediate cross-vein is situated at the centre of the discal cell and the first posterior is rather long.

Variation.—Victorian specimens vary slightly from those of New South Wales and this is specially noticeable in the lighter colour of the abdomen, on the segments of which a median brownish spot is usually traceable.

Length, male 11-14 mm., female 15 mm.

Hab.—New South Wales: Narrabeen and Blackheath, October to November, 1919-1921, 4 males, 3 females. Victoria: W. Warburton, 15 December, 1918, 1 male, 1 female (C. E. Cole) in the National Museum. Further specimens consist of one female bred by Miss V. Irwin Smith, and five others in the Macleay Museum.

Observations.—Macquart's species, *Asilus fulvipubescens*, has hitherto been unrecognized, but the form here described is the only species I have seen that conforms to Macquart's description. The type was not seen by Miss Ricardo and was described from Bigot's collection, and so its whereabouts, if in existence, are unknown; on this account a pair has been labelled "Neotype".

CERDISTUS MARICUS Walker.

Asilus maricus Walker, *Ins. Saund. Dipt.*, 1851, 141; List Dipt. Brit. Mus., viii, suppl. 3, 1855, 735.—*Cerdistus maricus* Ricardo, *Ann. Mag. Nat. Hist.* (8) ii, 1913, 436, and (9) i, 1918, 63.—*Cerdistus sydneyensis* Schiner, *Reise Novara Dipt.*, 1868, 187; Ricardo, 1913 and 1918.—*Neoitamus sydneyensis* Hardy, PROC. LINN. SOC. N.S.W., xlv, 1920, 191, fig. 4.

Synonymy.—Originally I described this species from a series amongst which there was a female identified by Miss Ricardo as *Cerdistus sydneyensis* Schiner. I now find in the Gibbons collection, a further female identified by Miss Ricardo as Walker's species. Certainly Walker's description fits the form described by me under Schiner's name, but Miss Ricardo evidently regards the two descriptions as belonging to two forms. There is a confusion here, for either the two are truly identical or else a complex of forms is standing under these names. It seems advisable to regard Schiner's name as being a synonym until such times as the types become available for study.

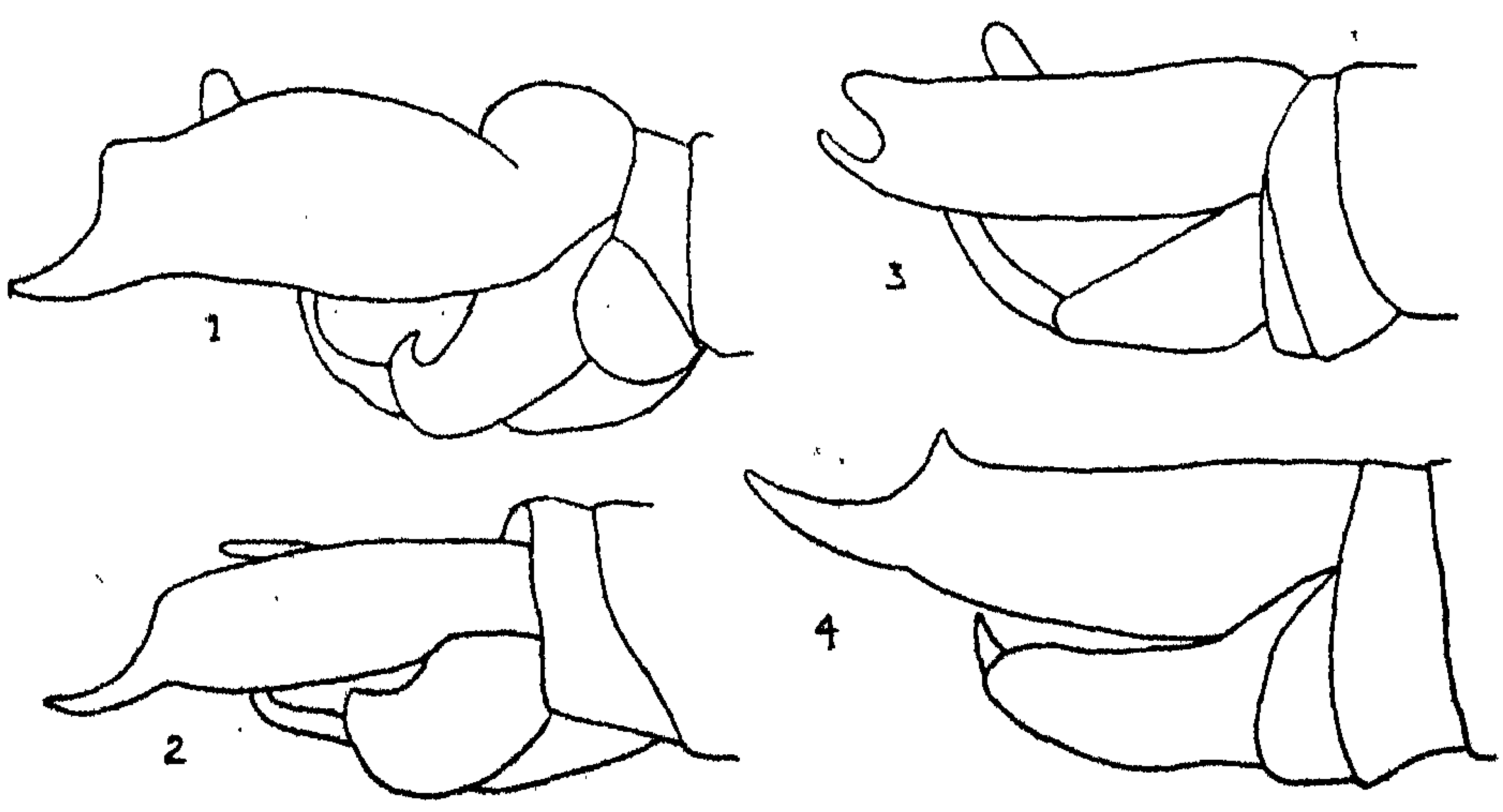
CERDISTUS LAUTUS White.

Rhabdotoitamus lautus White, *Proc. Roy. Soc. Tasmania*, 1917, 101.

R. lautus White is the same in structure as *C. fraternus* Macquart, but is different in colour, is smaller in average size and the female has a slightly longer ovipositor.

Hab.—Victoria: W. Warburton, 1 male, 1 female, Fenshaw, 1 male, Ferntree Gully. December, 1918 (C. E. Cole).

Observation.—Whereas this species has been found to occur only in Victoria, *C. fraternus* Macquart is only known from Tasmania, so it is possible to regard this lighter form as being a subspecies of the island type.



Figs. 1-4. Male genitalia of *Cerdistus*. 1, *C. rusticanoides*, n. sp. 2, *C. fulvipubescens* Macquart. 3, *C. gibbonsi* Ricardo. 4, *C. rudis* (Walker) White.

CERDISTUS GIBBONSI Ricardo. Text-fig. 3.

Neoitamus gibbonsi Ricardo, *Ann. Mag. Nat. Hist.* (9) i, 1918, 64.—*Neoitamus hyalinipennis* White (*nec* Ricardo), *Proc. Roy. Soc. Tasmania*, 1916, 175.

Synonymy.—I think there can be little doubt but that White's identification of *N. hyalinipennis* from Tasmania belongs here, but it is possible that more than one species has been incorporated by White under that name, including *C. armatus*. I have not seen *N. hyalinipennis* Ricardo, which is said to have the seventh abdominal segment subcompressed (i.e., forming part of the ovipositor as Miss Ricardo refers to it). The Gibbons collection contains authentic specimens and, moreover, according to the original description, there can be no doubt that the form referred to here is correctly identified. The species occurs abundantly.

Description.—A black species; the thick black moustache on the face contains a few white hairs only on the female. A row of black bristles occurs behind the eyes. The dorsal thoracic bristles are disposed on each side of the median line as follows: Two presutural, two supraalar, two postalar and about four dorsocentral. There are from two to six scutellar bristles and the meta- and hypo-pleural bristles are present. Usually all bristles black, sometimes some are white. The abdomen has two lateral black bristles on the first segment only. The upper forceps of the male genitalia are deeply emarginated so that the terminal processes appear to arise below an upper lobe-like process. The female ovipositor is long, a little longer than from the fifth to seventh abdominal segments inclusive. The intermediate femora have two bristles on the anterior side, a ventral row and a subapical bristle on the posterior side. The wings have a normal venation; the intermediate cross-vein is situated beyond the centre of the discal cell, and the first posterior cell is rather long.

Length, 18-23 mm. usually, but sometimes much smaller.

Hab.—New South Wales, Queensland and Tasmania. A long series of both sexes, including 6 males and 4 females from the last mentioned State.

Observations.—*C. gibbonsi*, *C. constrictus* and *C. conformis* have much in common and the females may sometimes be confused. It will be noted that the length of the ovipositor in *conformis* is between the lengths of the other two and so, when sorting females, it becomes possible to separate readily the two that have the undivided median thoracic stripe by noting if the ovipositor is longer (*constrictus*) or shorter (*gibbonsi*) than is the case of *conformis* which has a divided median thoracic stripe. All three forms are to be taken, sometimes plentifully in the same areas and during the same months and without some ready method of recognizing each, the certain identification of the three would be very laborious.

CERDISTUS RUDIS Walker. Text-fig. 4.

Asilus rudis Walker, List Dipt. Brit. Mus., vii, suppl. 3, 1855, 737.—*Dysmachus rudis* Ricardo, *Ann. Mag. Nat. Hist.* (8) xi, 1913, 422, and (9) i, 1918, 62; White, *Proc. Roy. Soc. Tasmania*, 1916, 172.—*Trichoitamus rudis* White, *ibidem*, 1917, 91.

A black species; the face is composed almost entirely of the tubercle and the moustache is black on the upper half and white on the lower. The black bristles in a row behind the eyes are unusually long. The dorsal thoracic bristles are disposed on each side of the median line as follows: Two presutural with which there may also be one or two others, two supraalar, one strong and one weak postalar and from four to eight dorsocentrals which alternate with rather long,

and strong hairs. These and the two scutellar, the meta- and hypo-pleural bristles are black. The abdomen contains one strong lateral bristle on the first segment and several on the third to eighth; on the latter segments the bristles are more numerous on the female and almost meet on the dorsum. The male genitalia are rather long and the tapering forceps contain an apical dorsal hump and a strong, horizontally directed process that issues from the lower half. The female ovipositor is very short and compressed. The intermediate femora have a row of three bristles on the anterior side, a ventral row that is placed well towards the anterior side, looking like a second row thereon, and a subapical bristle on the posterior side. The posterior femora have the bristles similarly disposed, but the rows are more complete. The wing venation is normal, the intermediate cross-vein is situated beyond the centre of the discal cell, and the first posterior cell is short.

Length, 10-12 mm.

Hab.—Tasmania: Hobart, male and female in the National Museum, taken respectively on the 29th and 1st October, 1916, by C. E. Cole. Although not necessarily conspecific with the Tasmanian forms, further specimens are included under this name: A male from Mosman Bay, Sydney, and a female with an *Athcrimorpha* (Leptidae) as prey labelled "N. S. Wales" and having a completely black moustache, also a male and two females from Kosciusko, December, 1921 (G. A. Waterhouse). I have a rough sketch which I made from a Melbourne specimen in the National Museum and this, being the type locality, probably represents the form of genitalia on the typical species, but the one described above, which differs in the genitalia, is undoubtedly the form referred to by White under Walker's name and would be the genotype of his proposed genus *Trichotoitamus*. Until such times as sufficient material has accumulated for the purpose, it seems better to refrain from any attempt to separate the undoubtedly distinct species occurring amongst the complex here referred to under Walker's name.

Cerdistus armatus Macquart.

Asilus armatus Macquart, *Dipt. Exot.*, suppl. 1, 1864, 91, pl. 8, fig. 17.—*Neoitamus armatus* Hardy, Proc. Linn. Soc. N.S.W. xlv, 1920, 185, fig. 10, which see for synonymy and references.—*Asilus elicitus* Walker, *Ins. Saund. Dipt.*, 1851, 139; Ricardo, *Ann. Mag. Nat. Hist.* (8) xi, 1913, 447.

Synonymy.—In the National Museum there is a specimen of *Cerdistus armatus* that, although broken and in very bad condition, shows the essential characters by which this species is recognizable; this specimen was named by Walker as his *Asilus elicitus*, the type of which is apparently lost, therefore the opportunity is taken to place Walker's name as a synonym on the evidence of this authentic specimen.

Cerdistus claripes White. Text-fig. 5.

Rhabdotoitamus claripes White, *Proc. Roy. Soc. Tasmania*, 1917, 98, *nec* Hardy, 1920.—*Neoitamus australis* Ricardo, *Ann. Mag. Nat. Hist.* (9), i, 1918, 65.

Synonymy.—This name was given by White to a species, specimens of which were taken by Dr. E. W. Ferguson. Later Dr. Ferguson showed me specimens taken from the same locality which agreed with White's description. Major E. E. Austen, however, who kindly compared my drawing of the latter with the type at the British Museum, gave me enough information to suggest that I had misidentified White's species, so subsequently the name of the second form was

changed to *neoclaripes*. Again, from the same locality, Dr. Ferguson has taken specimens that not only conform to White's description, but also have the shorter upper forceps mentioned as the main difference from *neoclaripes* by Major Austen, and I have not been able to distinguish any further differences between the two forms. That these really do represent distinct species is not at all clear, but the genitalia in the first case illustrated show the upper forceps slightly attenuated upwards, whilst that of *claripes* is shorter, being without this apical attenuation.

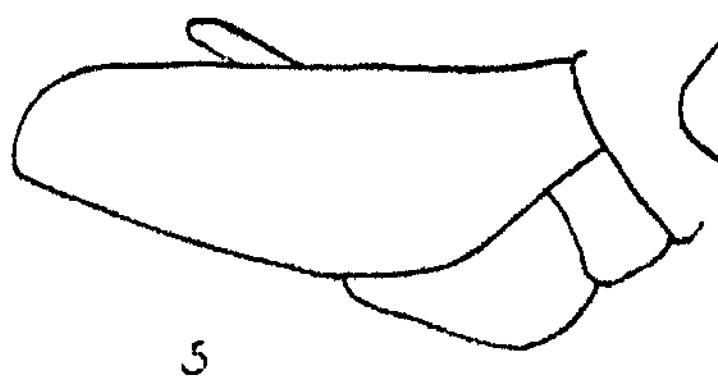
The description of *N. australis* Ricardo, agrees with specimens of *C. claripes* White and *C. neoclaripes* Hardy. The sketch of the genitalia of the type made by Mr. Brunetti agrees remarkably well with the drawing given here and the type locality is Roseville, Sydney, the locality of nearly all the Gibbons collection, and the same as that of one of White's two types.

CERDISTUS CONSTRICTUS, n. sp. Text-fig. 6.

Neoitamus grandis (Gibbons M.S.; Hardy M.S., name preoccupied); Irwin Smith, PROC. LINN. SOC. N.S.W., xlviii, 1923 (1924), p. xxx.

Synonymy.—In the Gibbons' collection recently acquired by the Australian Museum, there is a specimen named *Neoitamus grandis* which I believe to be given by Gibbons prior to 1920, in a paper that was never published and apparently has been subsequently destroyed. Quite independently I have used the same name in my own manuscripts and some specimens in collections are named as such, but the name cannot now be used as Miss Ricardo has published it for a Ceylon species. The name here substituted, *constrictus*, refers to the subapical constriction of the upper genital forceps, on the male.

Description.—A very robust species. Male: Face with a tubercle covering half its length and very prominent; front and face black, with yellowish tomentum bordering the eyes on the latter. Moustache normally black with about eight to ten white bristly hairs in the centre but sometimes it is predominantly white. Antennae, proboscis and palpi are black, the hairs on the latter and the beard



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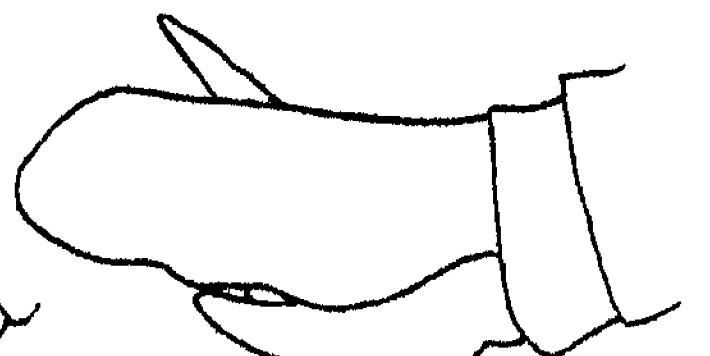

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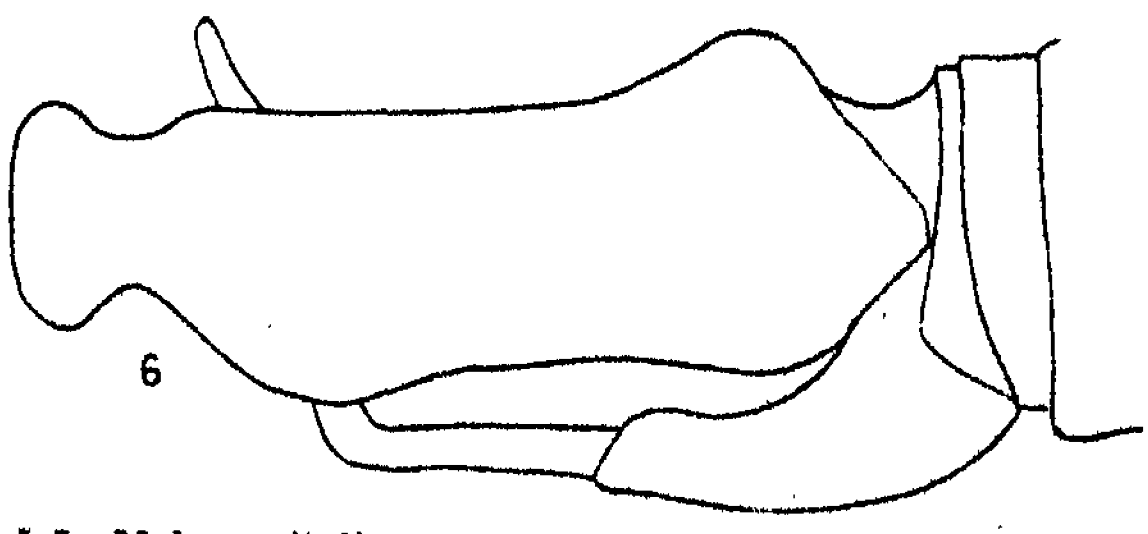

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Figs. 5-7. Male genitalia of *Cerdistus*. 5, *C. claripes* White; from a sketch. 6, *C. constrictus*, n. sp. 7, *C. conformis*, n. sp.

white. About four white bristles behind the eyes constitute the postocular row. Thorax with three black dorsal stripes alternating with lighter ones that are yellowish on the anterior half and grey posteriorly. The dorsal thoracic bristles are disposed on each side of the median line as follows: Two presutural, two supraalar, two postalar and about two or three dorsocentrals; most of these bristles are white. Two strong and two weak bristles on the scutellum. Metapleurals strong and black, the hypopleurals very weak and white. Dorsally the abdomen is black with yellow apical margins on the second to sixth segments, laterally and ventrally grey. Genitalia large, long and black, covered with black bristly hairs and a few white ones placed apically; upper forceps with a subapical constriction. Legs black, the basal third of the posterior femora and at least two-thirds of all tibiae are red. The intermediate femora have two bristles on the anterior side, a ventral row and a subapical bristle on the posterior side; the posterior femora have their bristles disposed in a similar manner except that the ventral ones are fewer in numbers, longer, and restricted to the apical half of the row. The wing venation is normal, with the intermediate cross-vein situated well beyond half the length of the discal cell and the first posterior cell is short.

Female: Similar to the male, but the moustache usually contains more white hairs. The ovipositor is exceptionally long and broad, being about the length of from the third to the seventh abdominal segments inclusive.

Length, males normally 18 mm., females 23-25 mm.

Hab.—New South Wales: Clarence River, Ebor, Narrabeen (holotype and allotype), Sydney, Como, Blackheath and Kosciusko; October to December, 1914-1920. Queensland: Blackall Range, Tambourine Mt., Brisbane. Seven paratypes are in the National Museum, three males and one female were bred by Miss V. Irwin Smith and there are eighteen further paratypes in various collections besides thirteen in my own. It seems incredible that such a robust and widely spread species had not been described by some earlier author, nevertheless it does not conform to any description so far published.

CERDISTUS CONFORMIS, n. sp. Text-fig. 7.

Moustache black, usually with a few white hairs in the centre and sometimes predominantly white. The postocular bristles are reduced to a short row, all white. The intermediate thoracic stripe is divided and the dorsal thoracic bristles are disposed on each side of the median line as follows: Two presutural, two supraalar, one or two postalar, five dorsocentral. These, the two scutellar and the metapleural bristles are black, the hypopleurals are few, weak and white. The lateral marginal bristles of the abdomen are white on the anterior, and usually black on the posterior segments, but all may be white. Specimens in very good condition have a silvery-grey tomentum covering two of the middle abdominal segments, but this is very seldom to be seen. The male genitalia are simple; the ovipositor is as long as the three and a half anterior segments. The legs are mainly black, the intermediate femora have one or two bristles on the anterior side, one subapical on the posterior side and a few scattered ventral bristles. On the posterior legs, one subapical on the anterior side and about three subapical on the posterior side, the ventral bristles are reduced to long and strong white hairs. Wing veins normal, the intermediate cross-vein is at about two-thirds the length of the discal cell.

Length, males 12-15 mm., females 15-18 mm.

Hab.—Victoria: Melbourne, Gisborne. New South Wales: Sydney, Narrabeen. Queensland: Stanthorpe, Brisbane. A very long series of both sexes. November to January, 1918-1924.

Observations.—This species conforms to *C. gibbonsi* and *C. constrictus* very closely, and some contrasting differences between the three are given under the description of the first mentioned.

CERDISTUS MARGITIS Walker.

Asilus margitis Walker, List Dipt. Brit. Mus., ii, 1849, 461.—*Neoitamus margites* (error for *margitis*) Hardy, PROC. LINN. SOC. N.S.W., xlv, 1920, 199, which see for further references.—*Asilus varifemoratus* Macquart, *Dipt. Exot.*, suppl. 4, 1850, 95.

Synonymy.—Now that the Tasmanian species of *Cerdistus* are so well known, it becomes possible to place those forms recorded from there, the descriptions of which were rather too scanty for earlier recognition. *Asilus varifemoratus*, according to its description, can only belong here, and thus the name is placed as a synonym. Possibly *Cerdistus australis* Ricardo will be found to belong here too.

CERDISTUS LATICORNIS Macquart.

Asilus laticornis Macquart, *Dipt. Exot.*, suppl. 1, 1846, 91; Walker, List Dipt. Brit. Mus., vii, suppl. 3, 1855, 735; Ricardo, *Ann. Mag. Nat. Hist.* (8) xi, 1913, 449.

Status.—This species had long been known to both White and myself, but White left it unnamed, not being able to separate it from *C. fraternus* (his *vulgatus*) with any assurance of success. It was, in his opinion, undoubtedly distinct, but approached small specimens of *C. fraternus* in most respects. From the shape of the male genitalia in the small series I possess, it appears at first sight that more than one species is incorporated, but it now transpires that the somewhat weak upper forceps are liable to dry out on pinned specimens into various distorted shapes. On this account the shape of the genitalia does not form a very reliable guide to the specific identity. Miss Ricardo refers to a short conical ovipositor on the type, but this is evidently an error in description.

Description.—Tubercle of face large, moustache with black hairs above and usually at the sides, the lower hairs are white. Bristles behind the eyes may be missing, but one row of black ones occurs when present. The dorsal thoracic bristles are disposed on each side of the median line as follows: Two presutural, two supraalar, one postalar, four to six dorsocentral. These and the two scutellar bristles black, metapleural mostly black, sometimes white, hypopleural very weak and white. The median thoracic stripe is undivided, by which character it can be readily separated from *C. fraternus*, on which this stripe is divided. Dorsal and usually lateral abdominal bristles are rather weak and black, ventrally they are white. Where these colours meet they may result in either two black lateral bristles or one white and one black. Upper forceps of male genitalia simple, having no definite characteristics, the shape depending on the amount of its curvature. Ovipositor short. The legs are black to a varying extent, the tibiae being brown from the base but having no definite limit. The first segment of the tarsi may also be tinged brown at the base. Intermediate femora with one bristle

placed centrally on the anterior side, one subapical on the posterior side and a few ventral bristles representing the anterior row only. Posterior femora with a few bristles representing the row on the anterior side, mainly reduced in size and white; two subapical bristles on the posterior side; the ventral rows are sparsely represented, many of these bristles are white. Intermediate cross-vein situated at a little beyond half the length of the discal cell.

Hab.—Tasmania: Garden Island, Lymington, Cygnet, Hobart, Mt. Wellington and Launceston. Nine males, eight females.

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(1926).

(a) GENERAL INDEX.

(b) BIOLOGICAL INDEX.

Synonyms are printed in *italics*; new names in SMALL CAPITALS.

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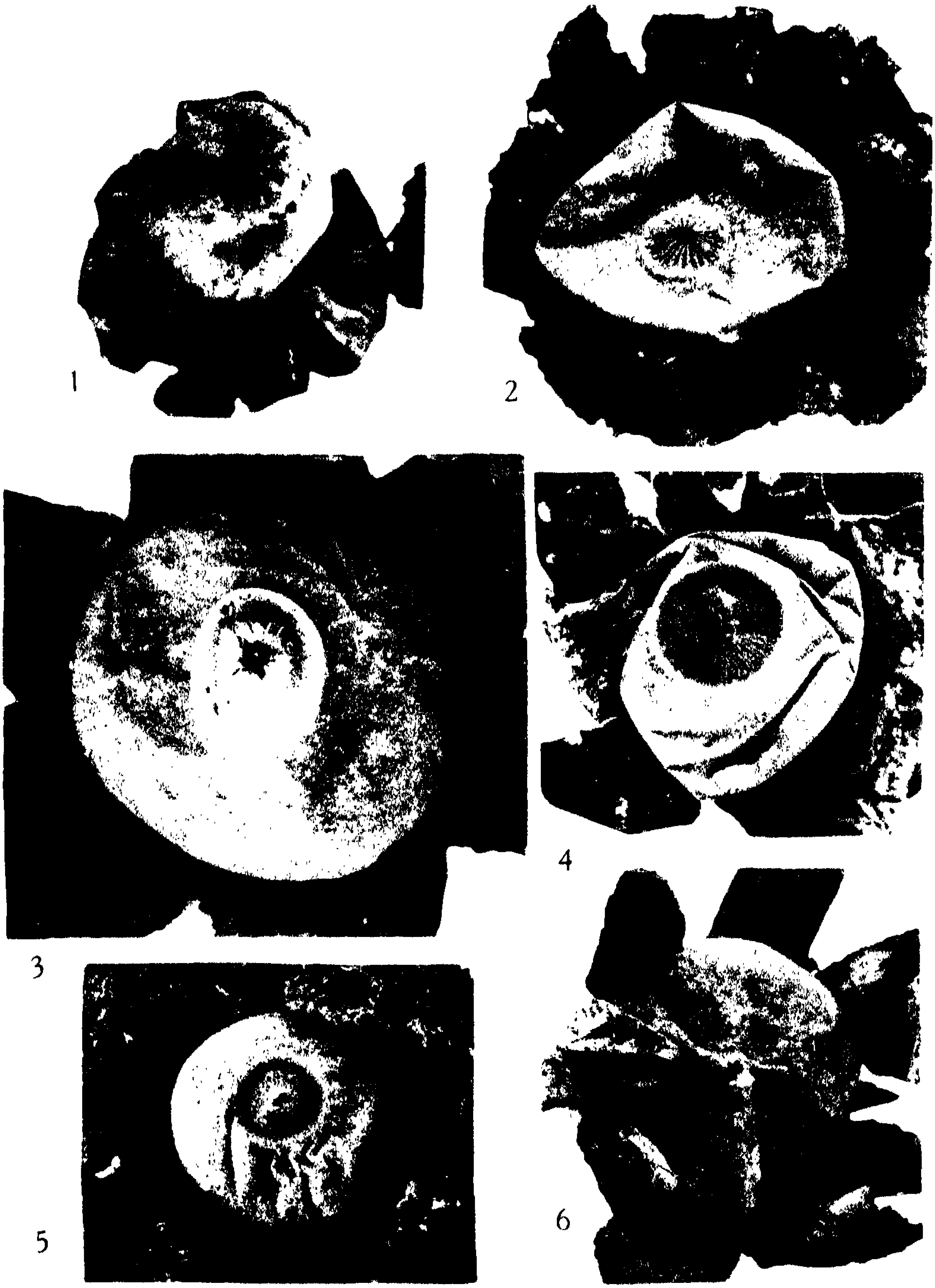
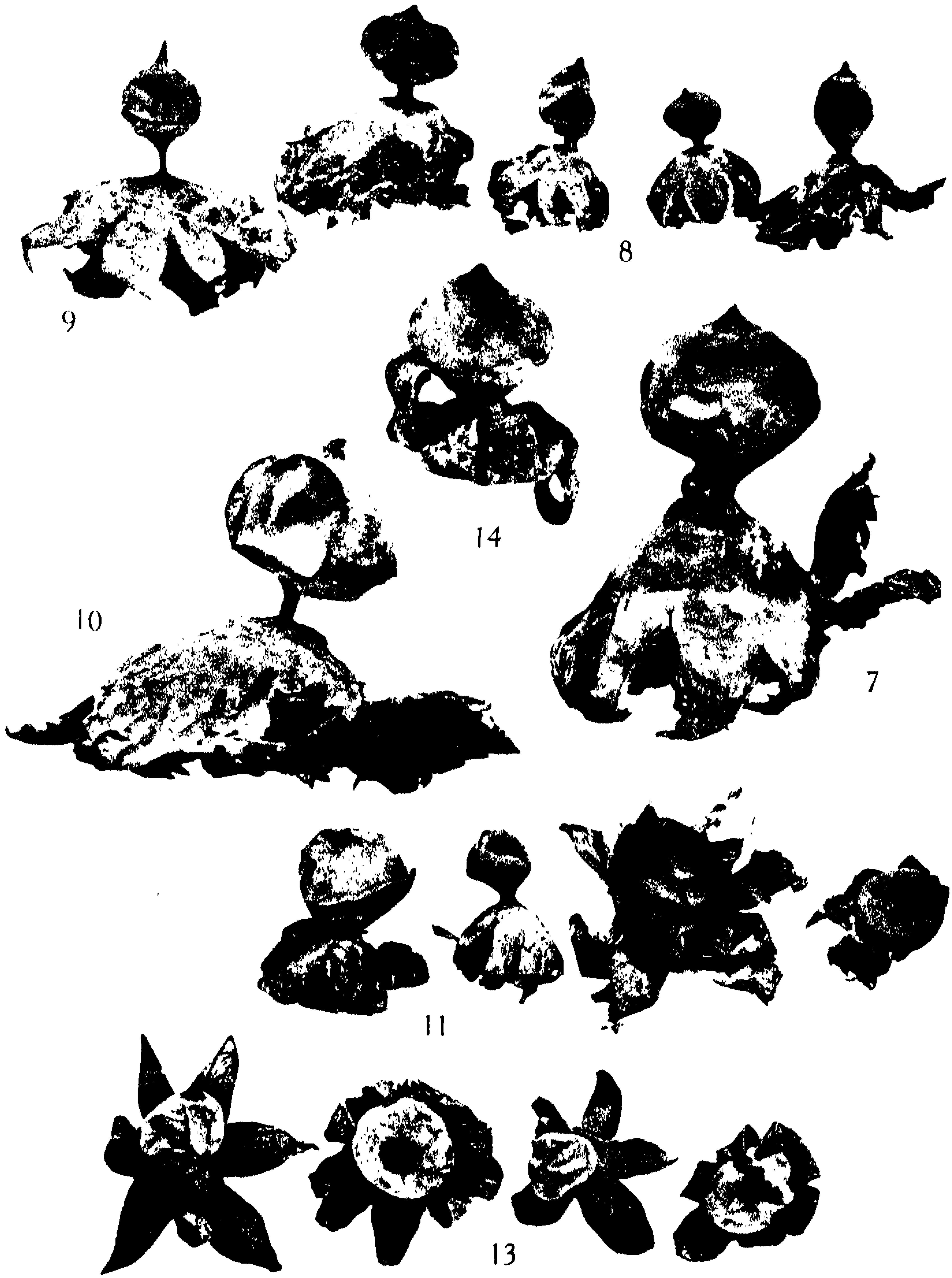
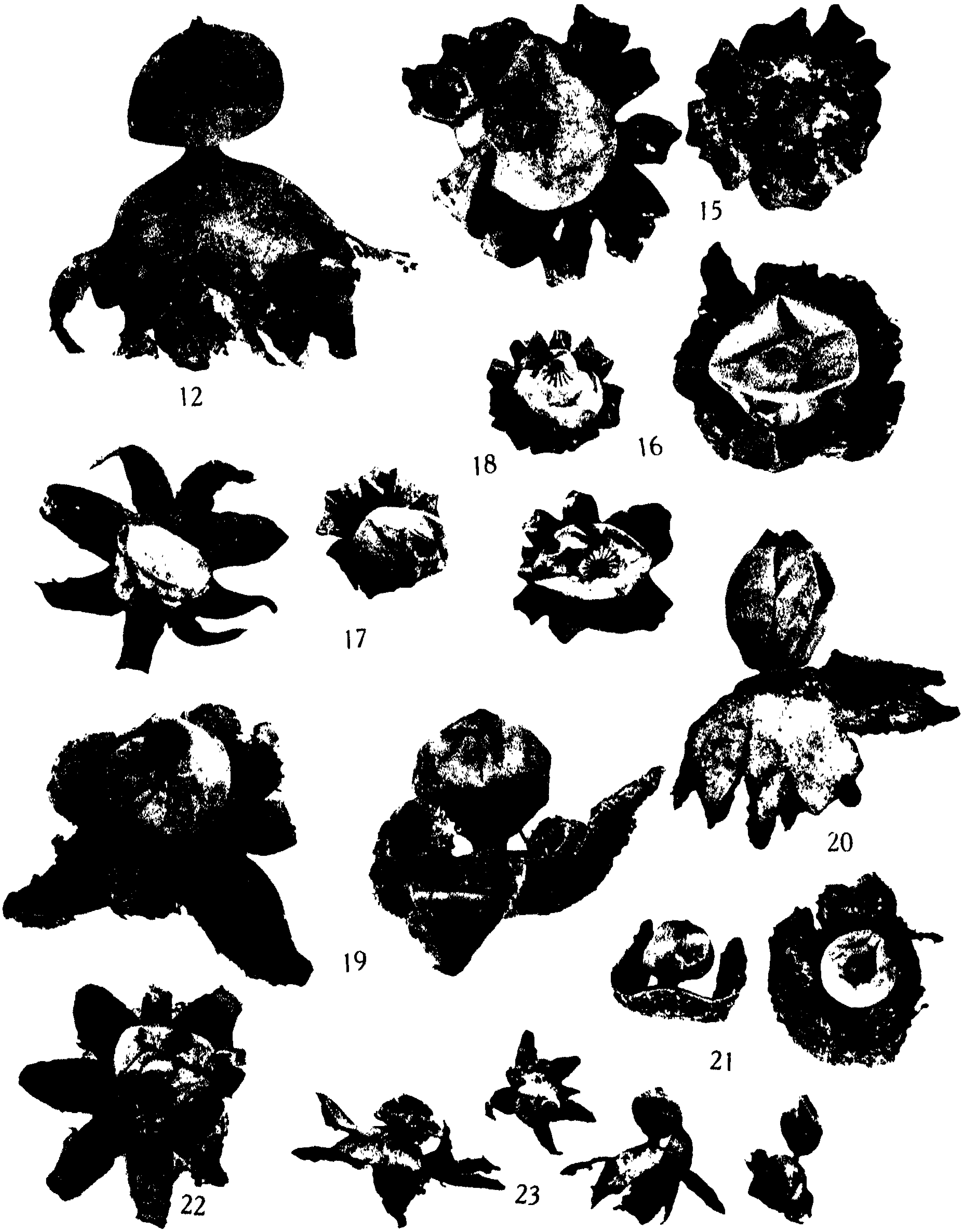


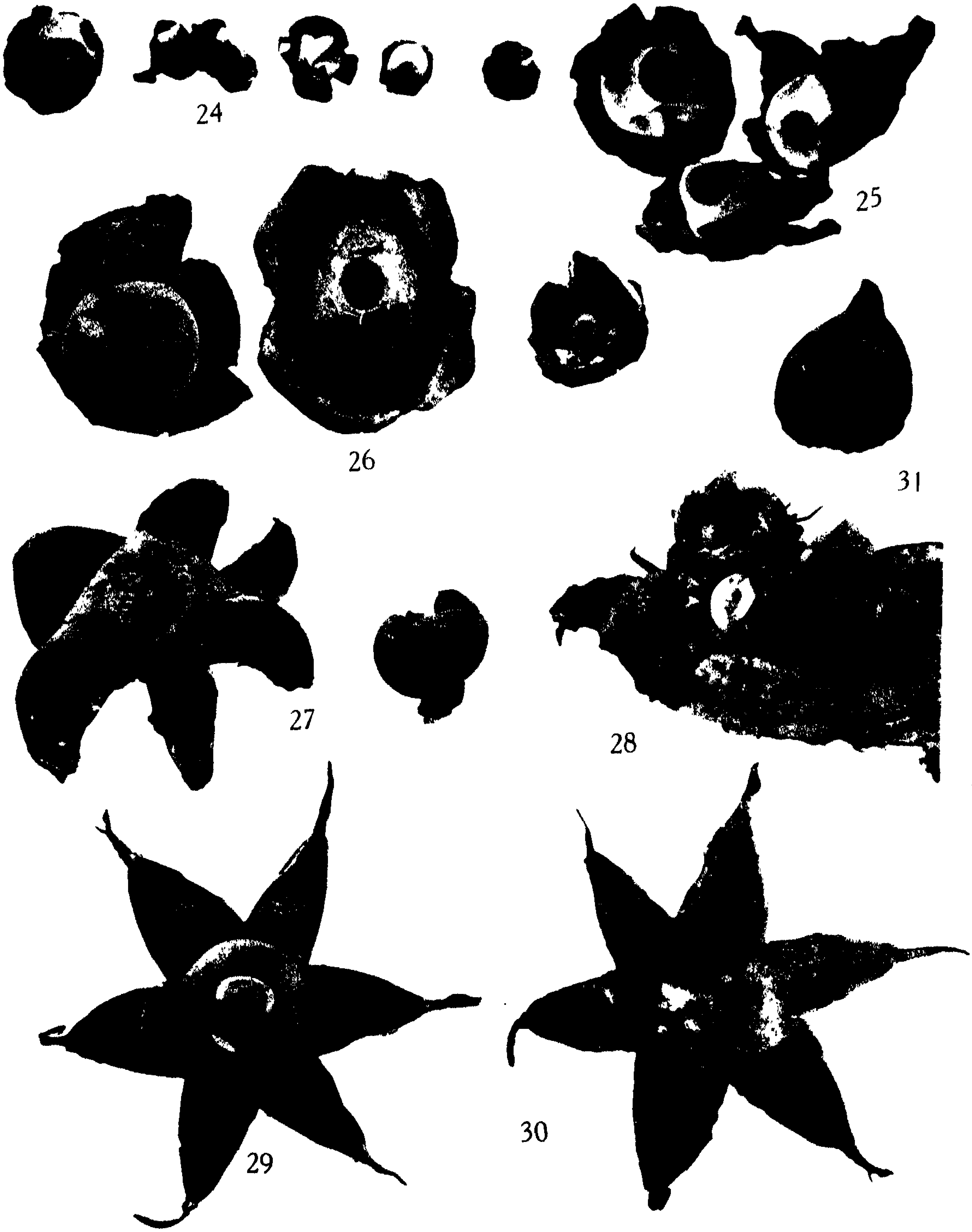
1. *Geaster campester.* 2. *G. Smithii.* 3, 4. *G. triplex.*
5. *G. limbatus.* 6. *G. floriformis.*



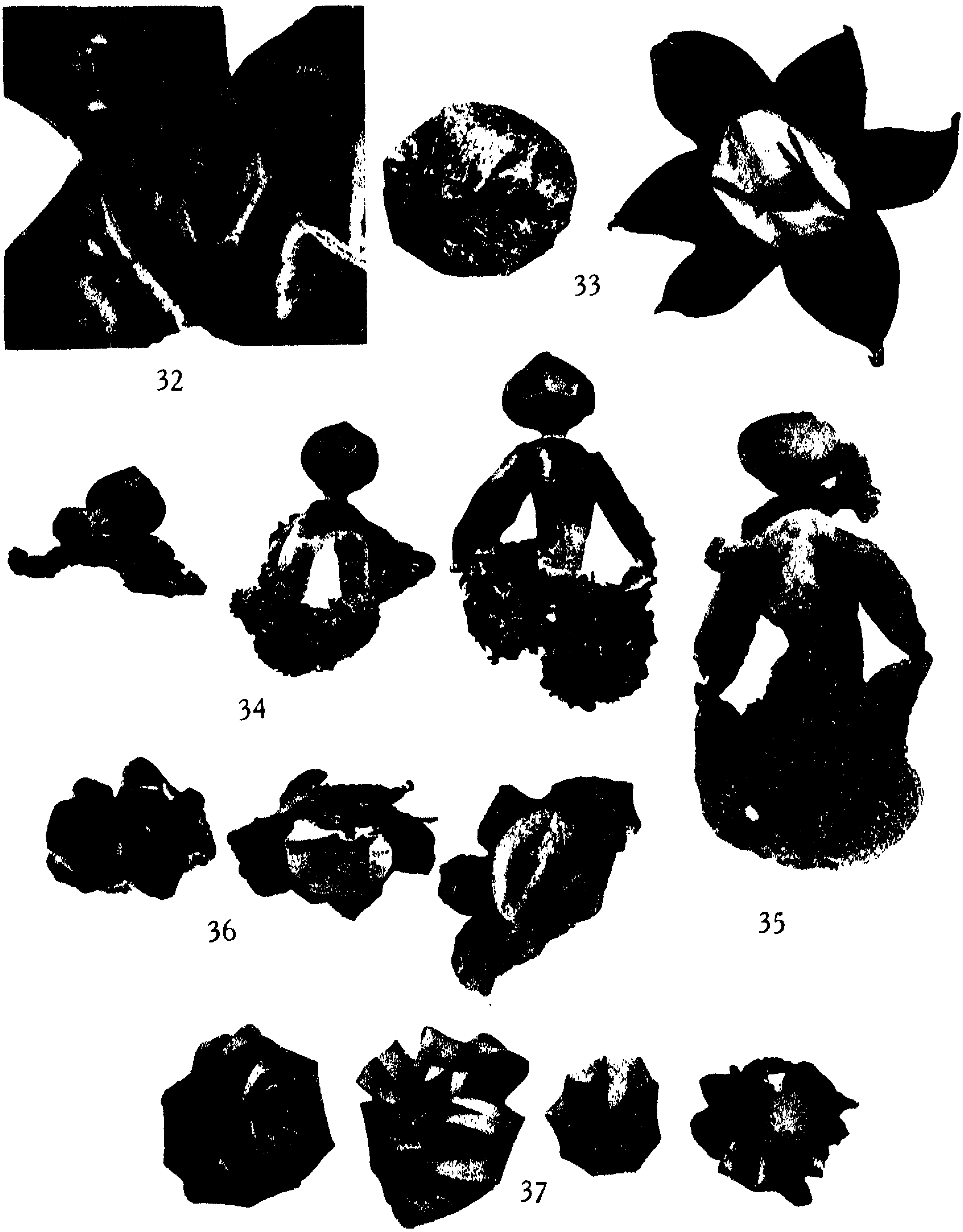
7, 8. *Geaster pectinatus.* *G. plicatus.* 10. *G. Bryanti.*
11. *G. ellipticis.* 13, 14. *G. campester.*



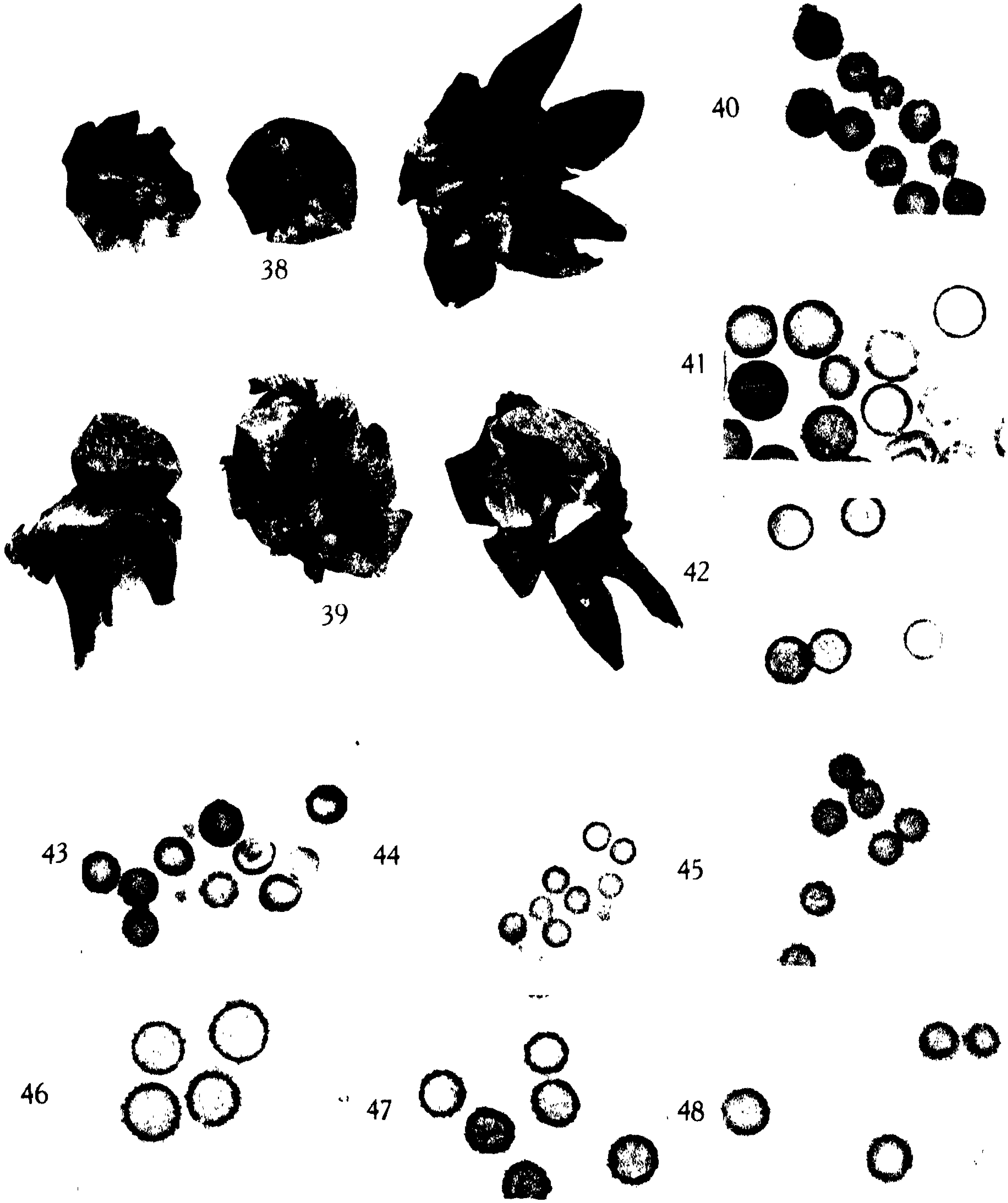
12. *Geaster Hariotii.* 15. *G. Clelandii.* 16. *G. Smithii.* 17, 18. *G. Drummondii.* 19-22. *G. limbatus.* 23. *G. minus.*



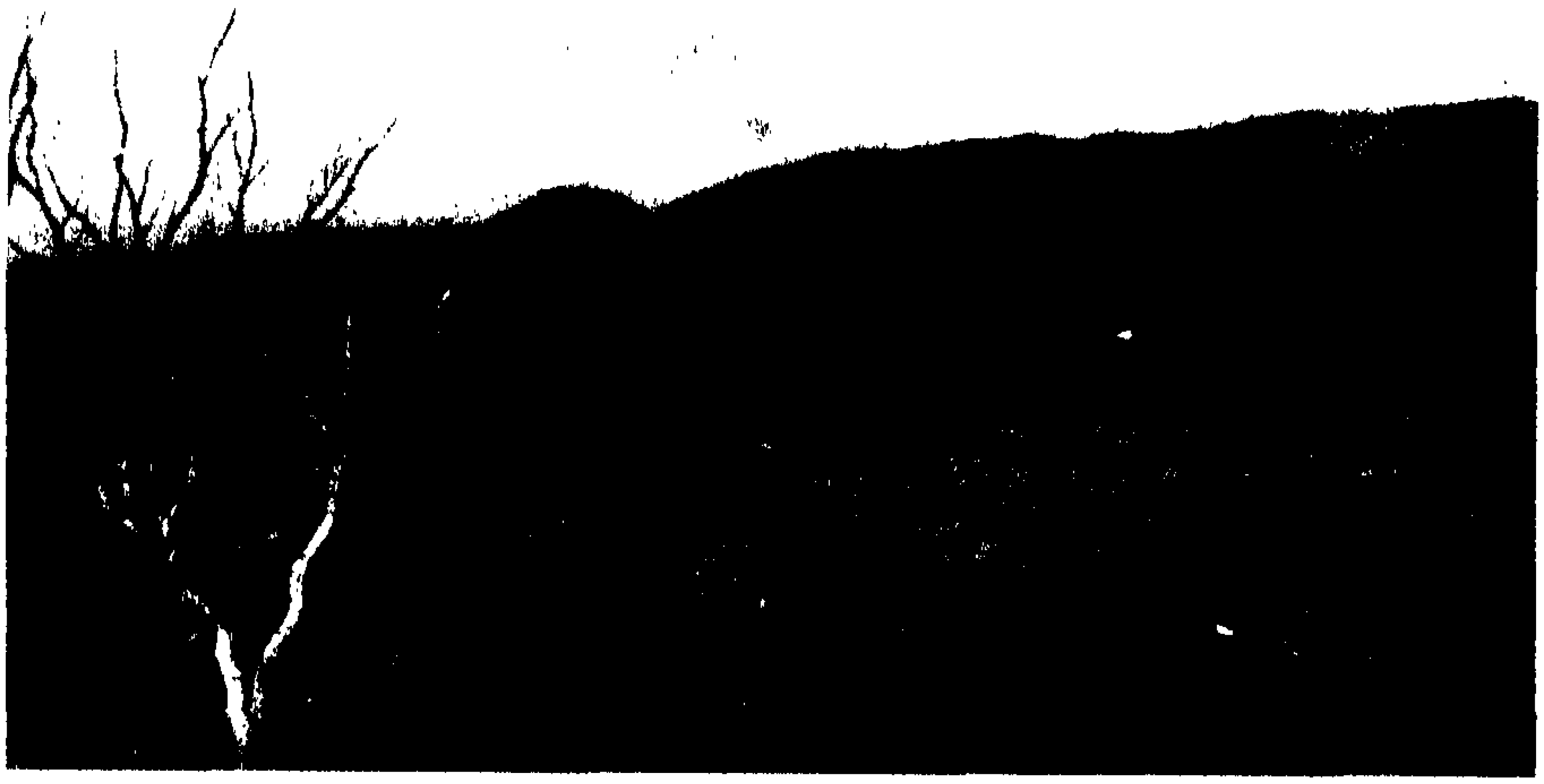
24, 25. *Geaster arenarius.* 26, 27. *G. velutinus.* 28. *G. mirabilis.*
29-31. *G. triplex.*



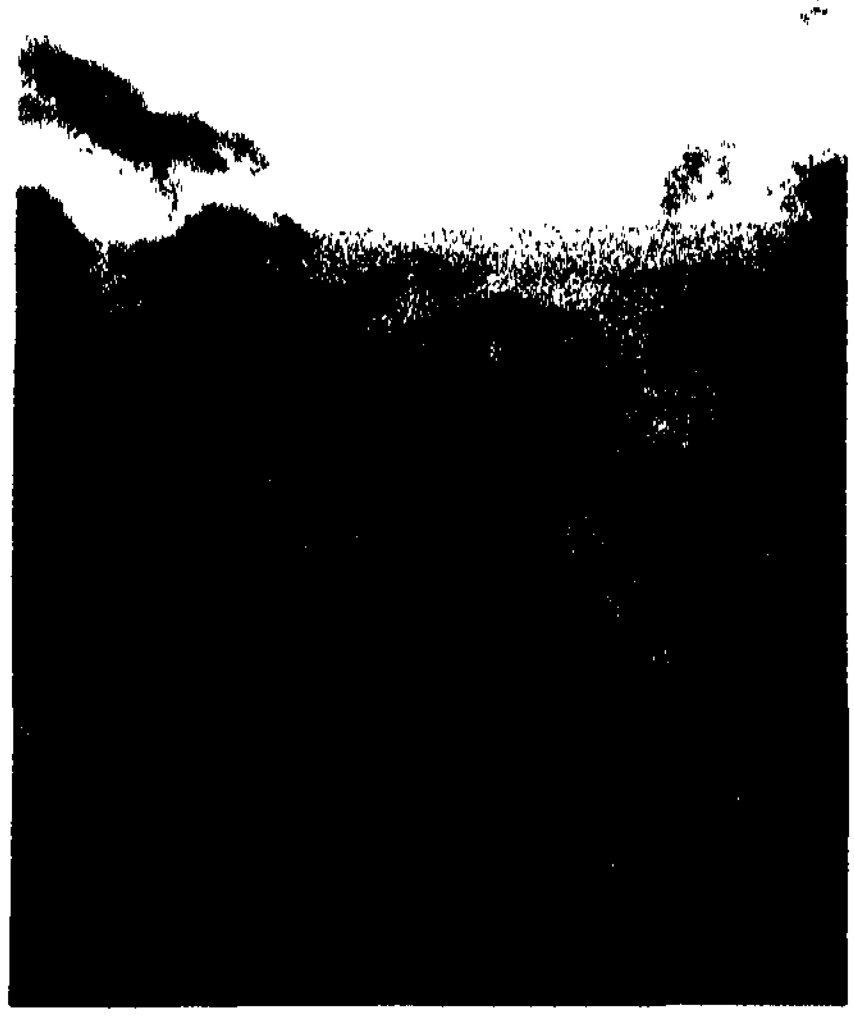
32. *Geaster triplex.* 33. *G. australis.* 34, 35. *G. fenestriatus.*
36. *G. fimbriatus.* 37. *G. floriformis.*



38. *Geaster floriformis*. 39. *G. simulans*. 40-48. Spores of species of *Geaster*.



1. General Topography of Mt. Wilson.
Ceratopetalum-Doryphora Rain-Forest in the deep gullies, and *Eucalyptus* Forest on most of the slopes.

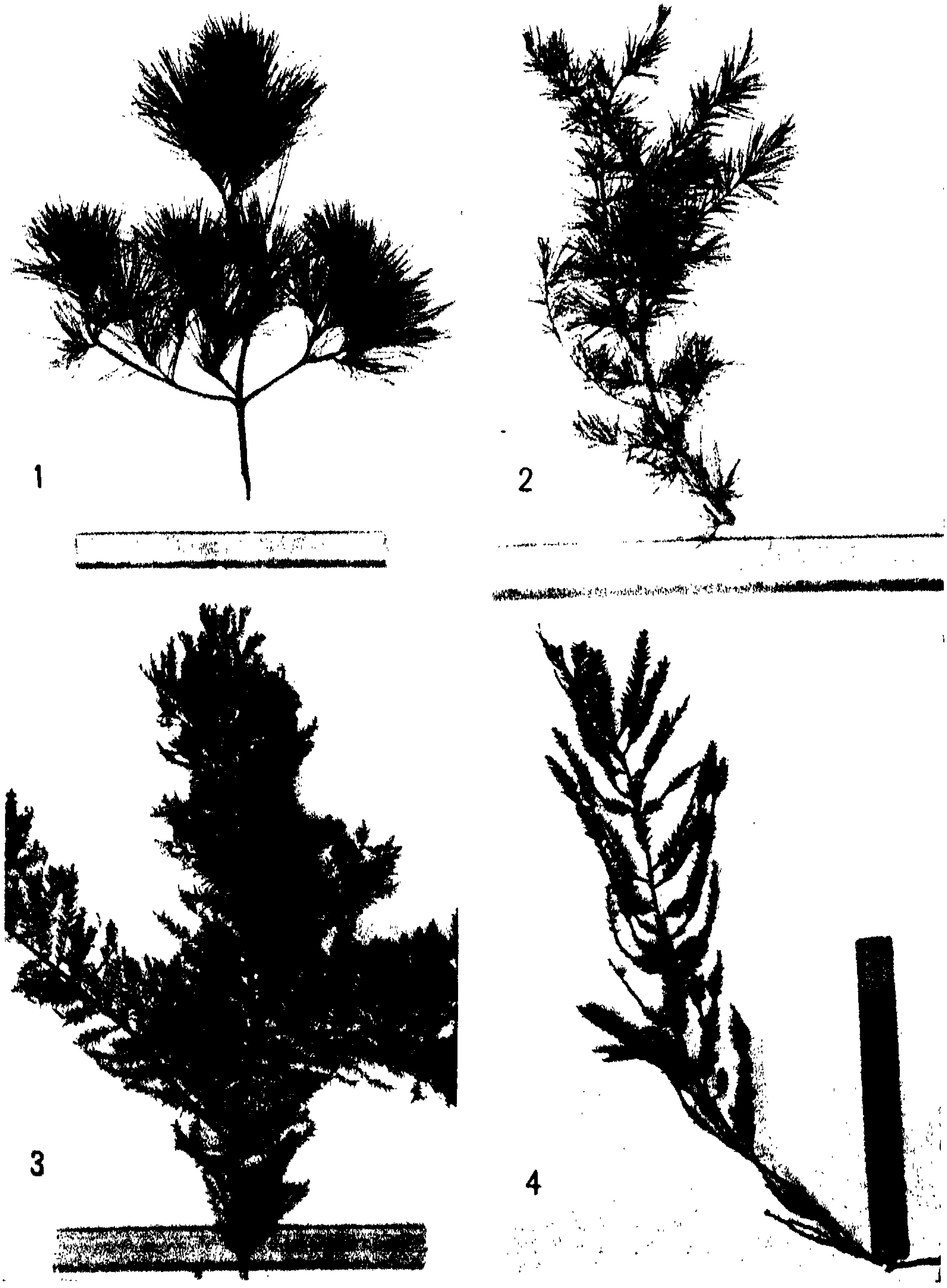


2. View of the Wollongambe Gorge.
Chiefly *E. piperita* Forest on the slopes; a narrow strip of *Ceratopetalum-Doryphora* Forest in bottom of gorge.

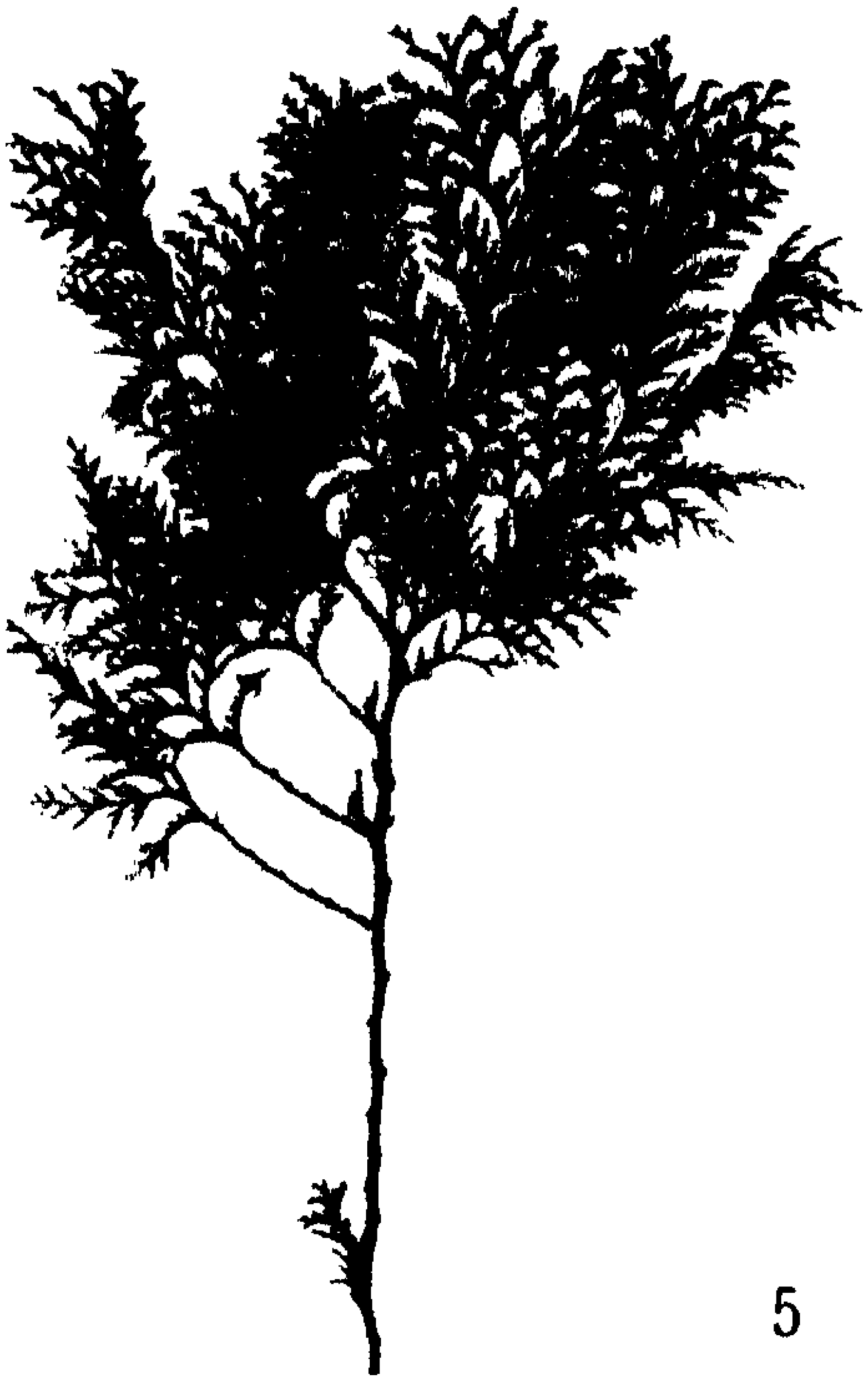
3. *Eucalyptus goniocalyx-E. Blaxlandi* Association showing the *Alsophila* stratum society.

4. The *Ceratopetalum-Doryphora* Association in a sandstone gully.

5. Interior of *Ceratopetalum-Doryphora* Forest on a southern sandstone slope.
6. *Eucalyptus oreades* Consociation.
7. Portion of *E. goniocalyx* Consociation given over to grazing.



1. *Pinus insignis*, 2. *Cedrus deodara*, 3. *Taxodium distichum*, and 4. *Sequoia sempervirens* showing dwarf shoots.



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5. *Chamaecyparis* showing branching and branch scars. 6, 7. *Araucaria Bidwillii.* Fig. 6 showing foliar branches; Fig. 7 showing scars where foliar branches have been shed.

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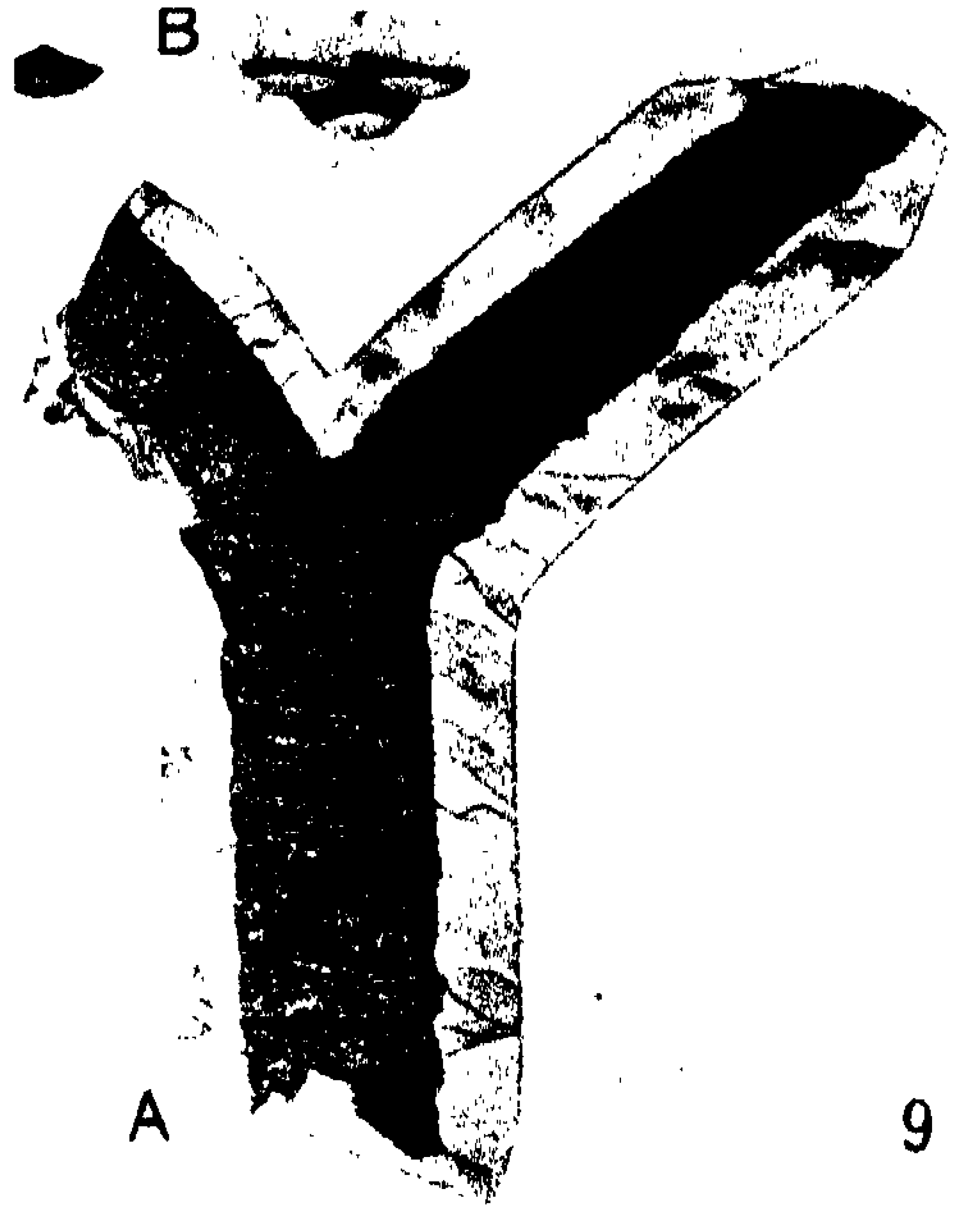

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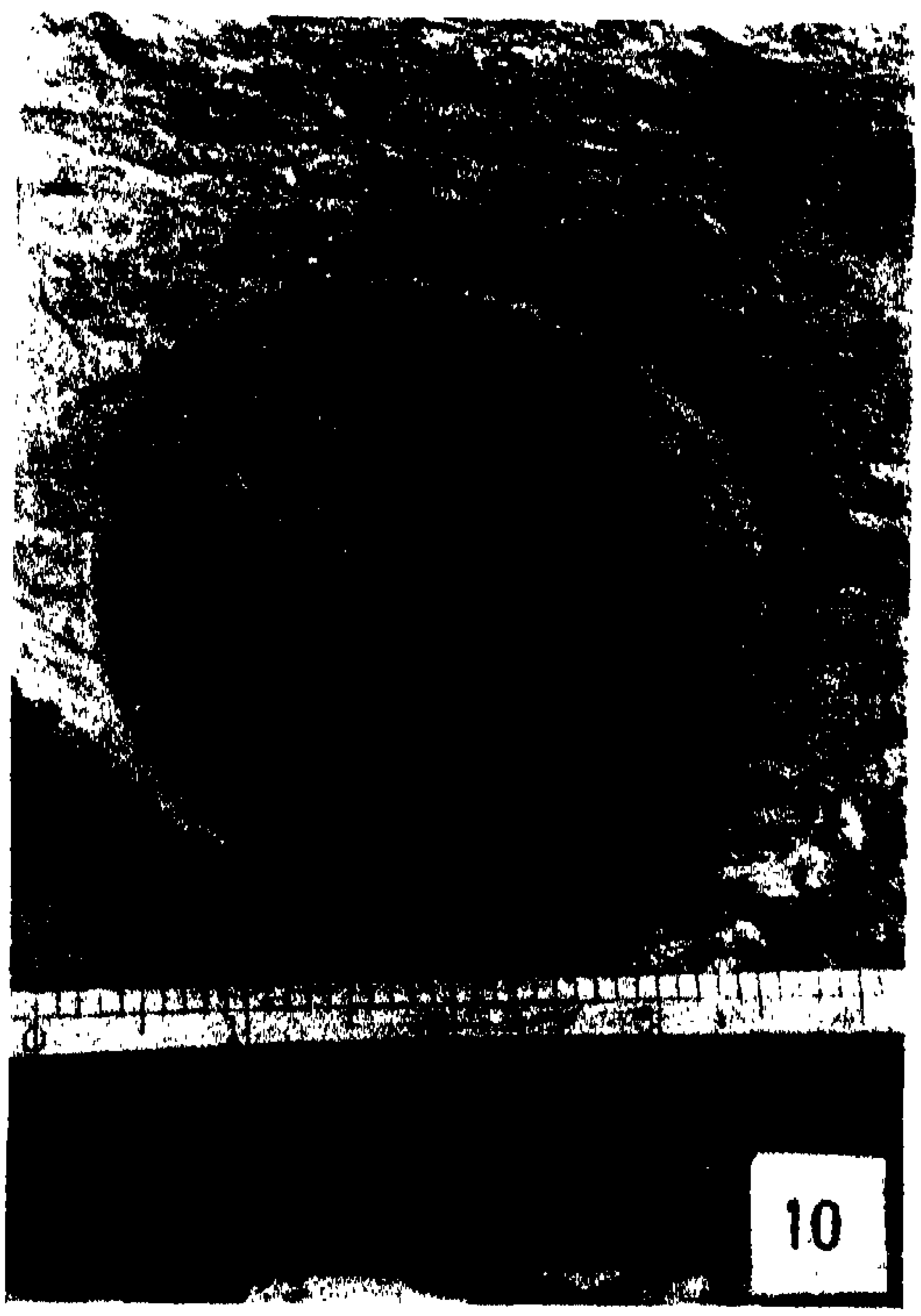
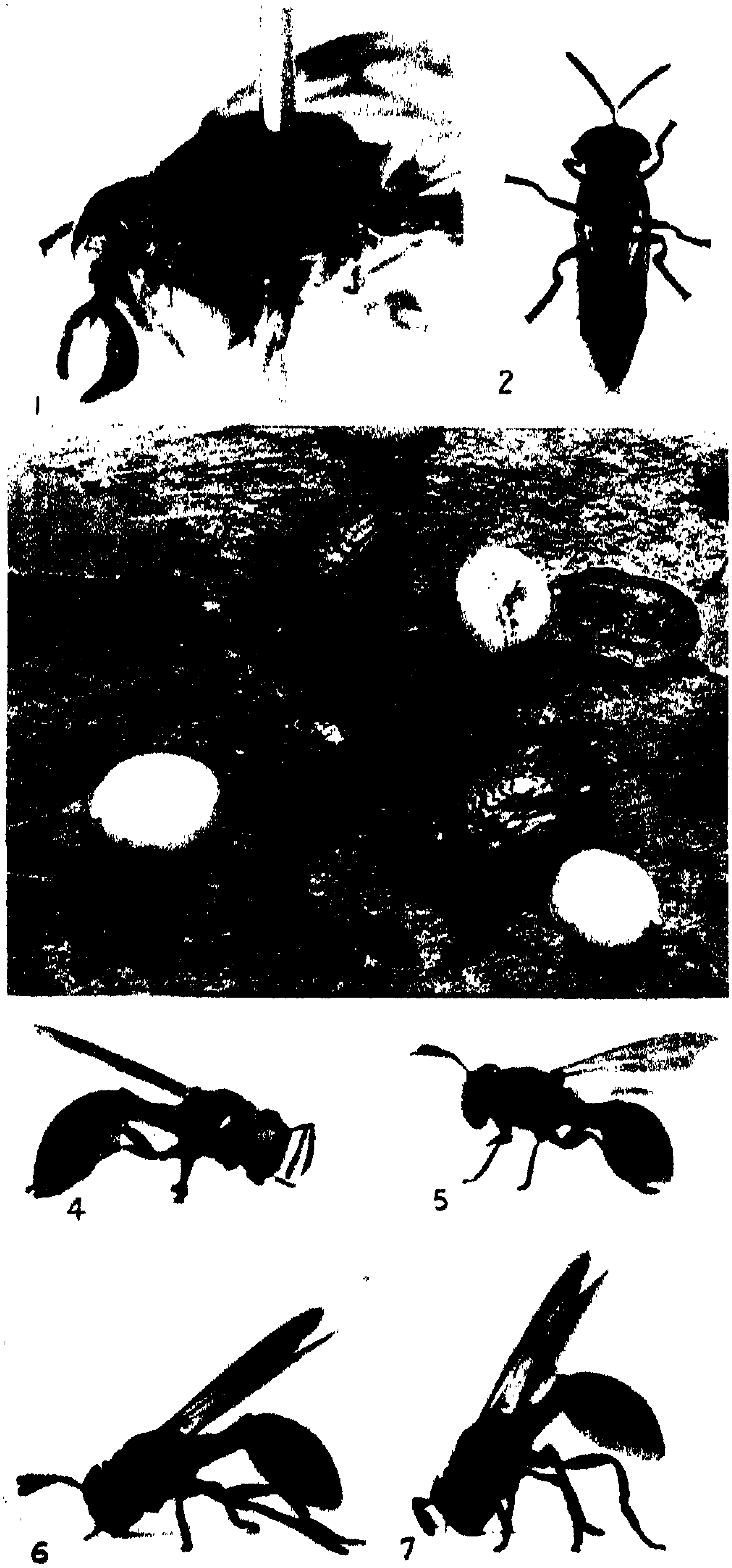


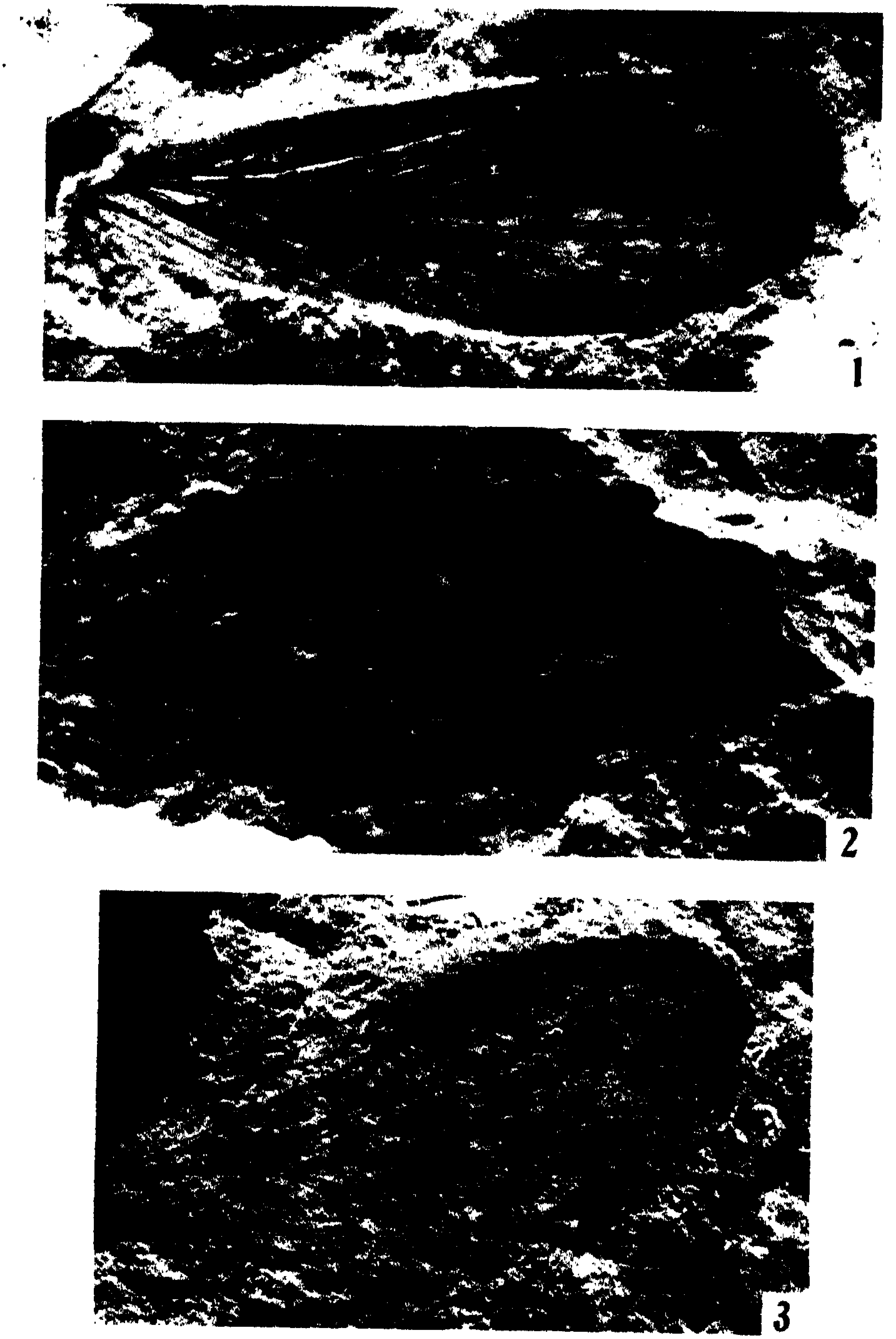
10

11

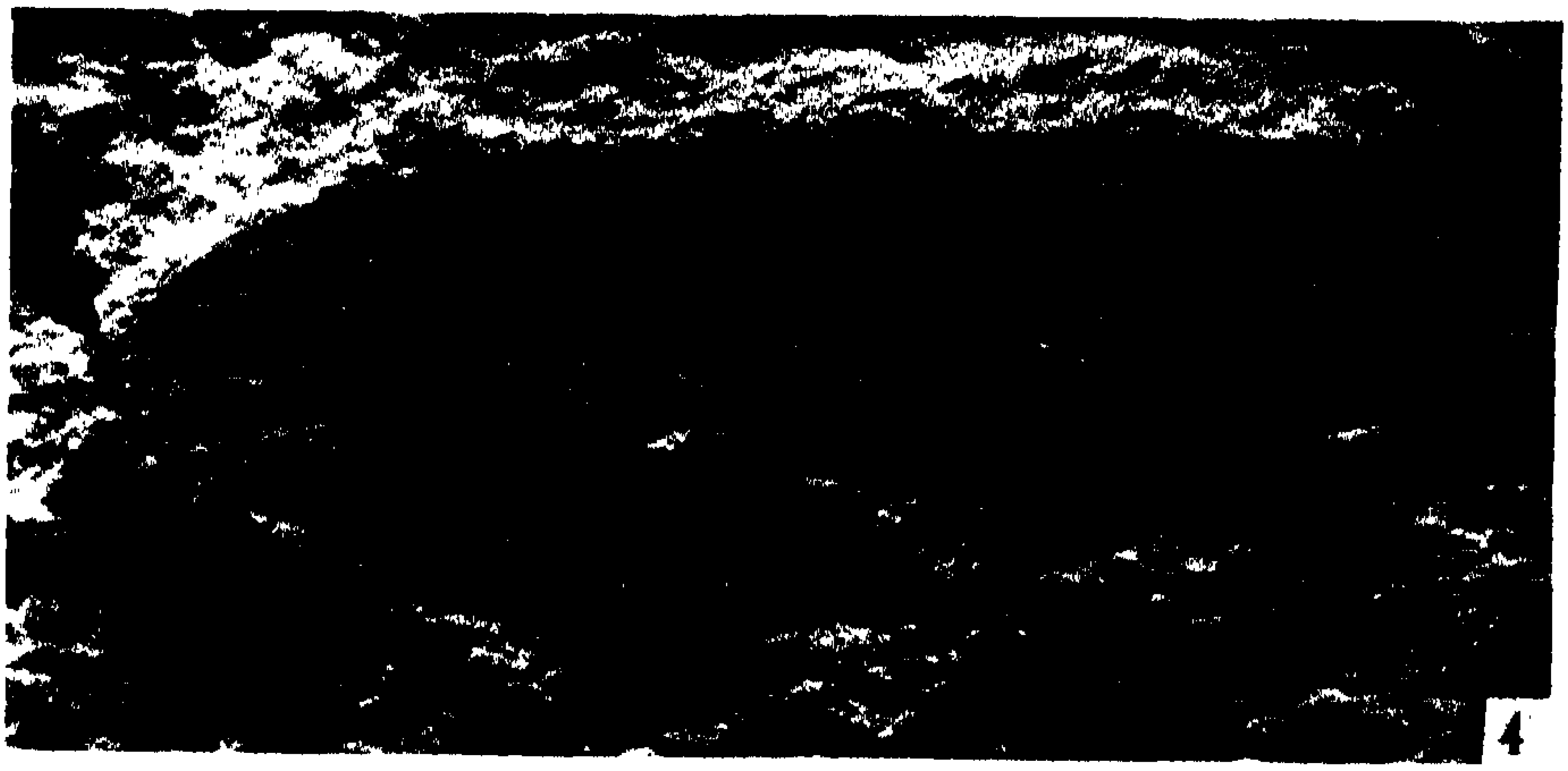
8. *Ulodendron* (after Scott). 9. *Halonia* (after Scott). 10. Ulodendroid scar from Wallarobba. 11. Branch scar on *Araucaria Cunninghamii*.



1. *Microdon alcicornis*, n. sp. 2-7. *M. variegatus* Walk.



1. *Permochorista jucunda.* 2. *Permochorista collinsi.*
3. *Parachorista pincombeae.*



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4. *Parachorista splendida.* 5. *Aphryganoneura anomala.*
6. *Permorapisma biserialis.*

Above.—*Jasminum Turneri.*
Below.—*Plectronia suborbicularis.*

1.

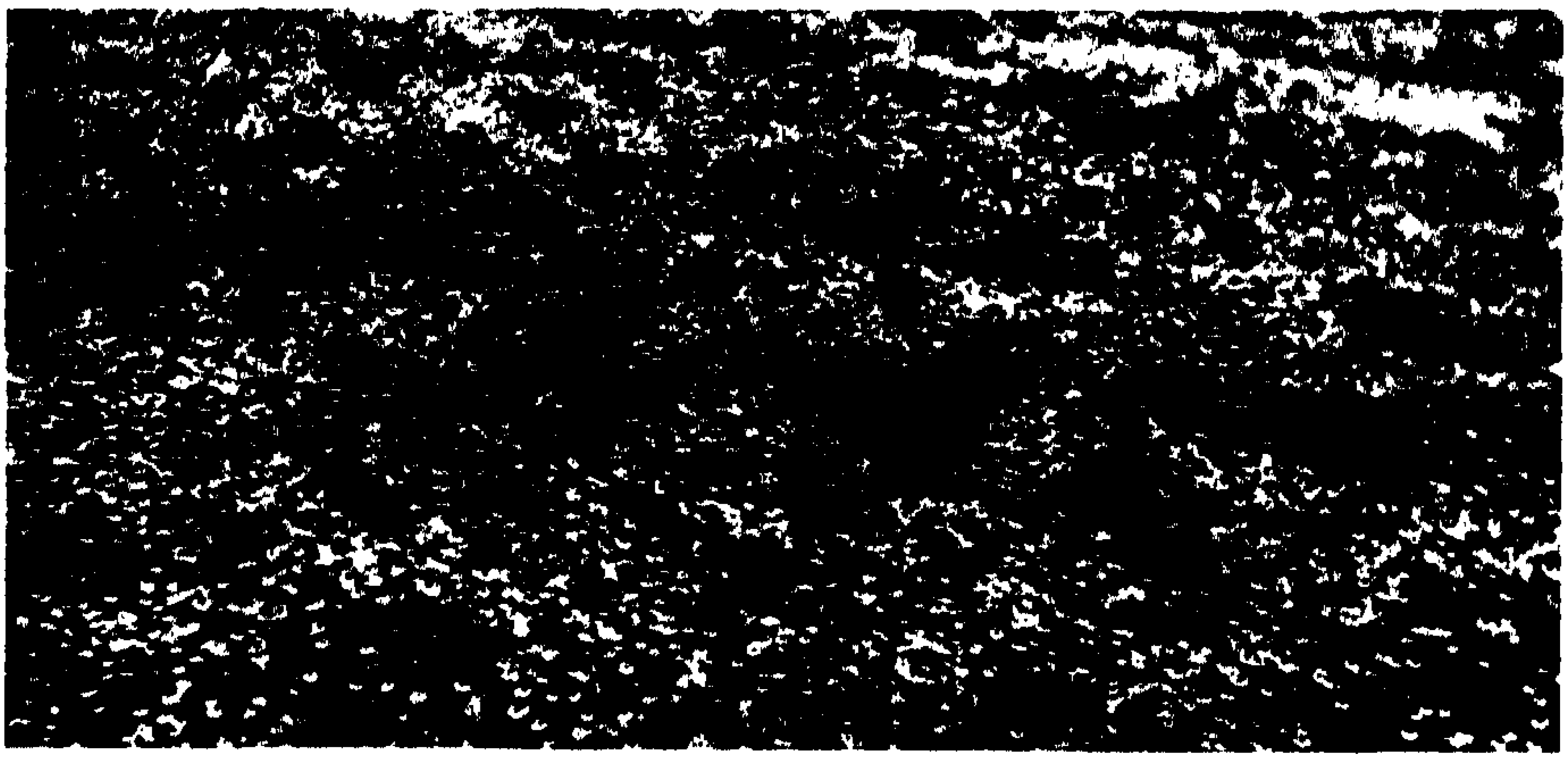
2.

1. *Eucalyptus terminalis.* Bloodwood. Mitchell's Sandridge, Thallon.
2. *Canthium oleifolium.*

3.
3. *Grevillea striata.* Beefwood.

4.
4. *Lyonsia eucalyptifolia.*

5.
5. *Eremophila Mitchelli.*

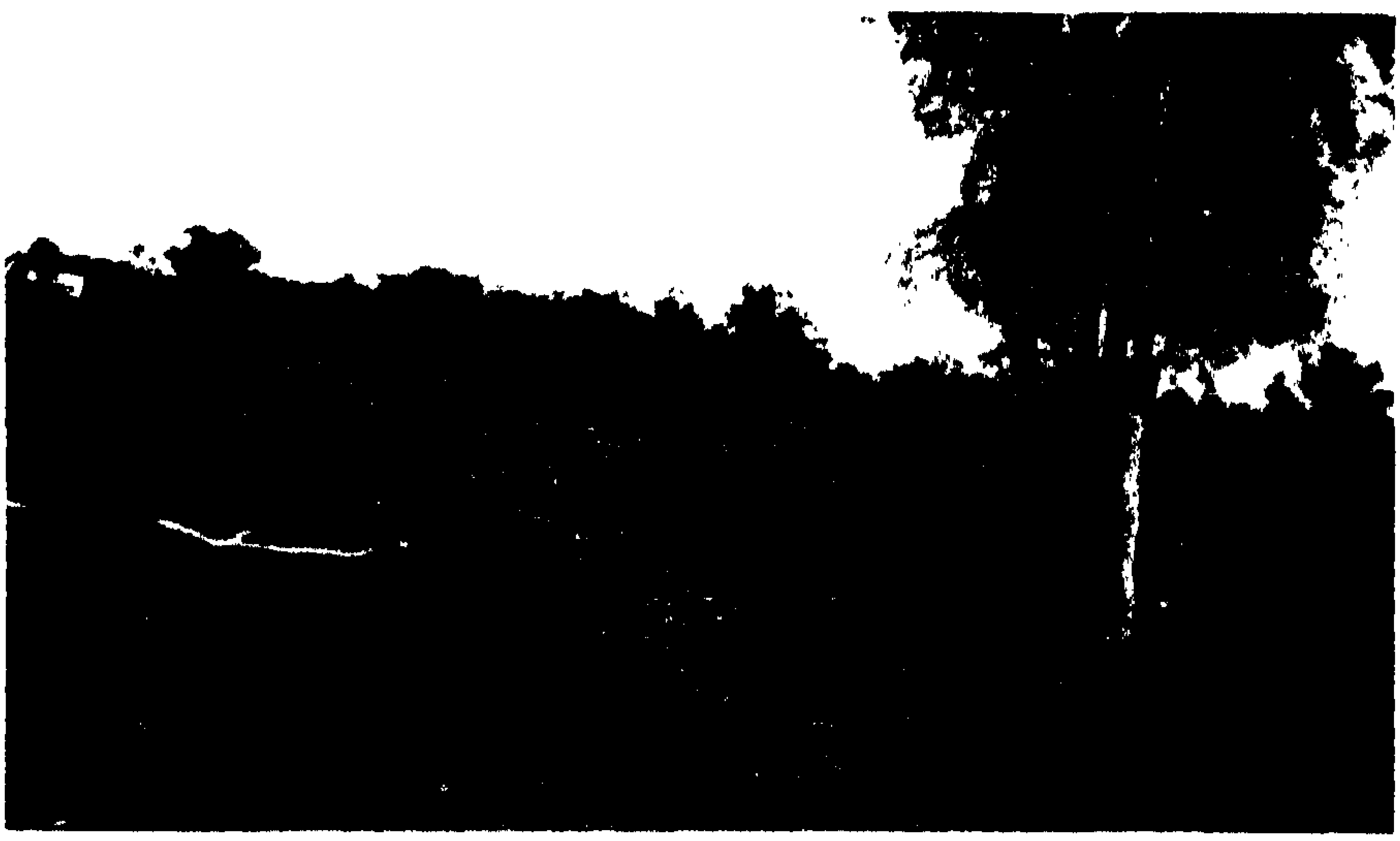


6. *Helipterum anthemoides.*

Angophora melanoxylon. Bumble Station.

8. *Eucalyptus terminalis*, on left; *E. tessellaris* (Carbeen, 2 white trees). *Opuntia* sp. in foreground.

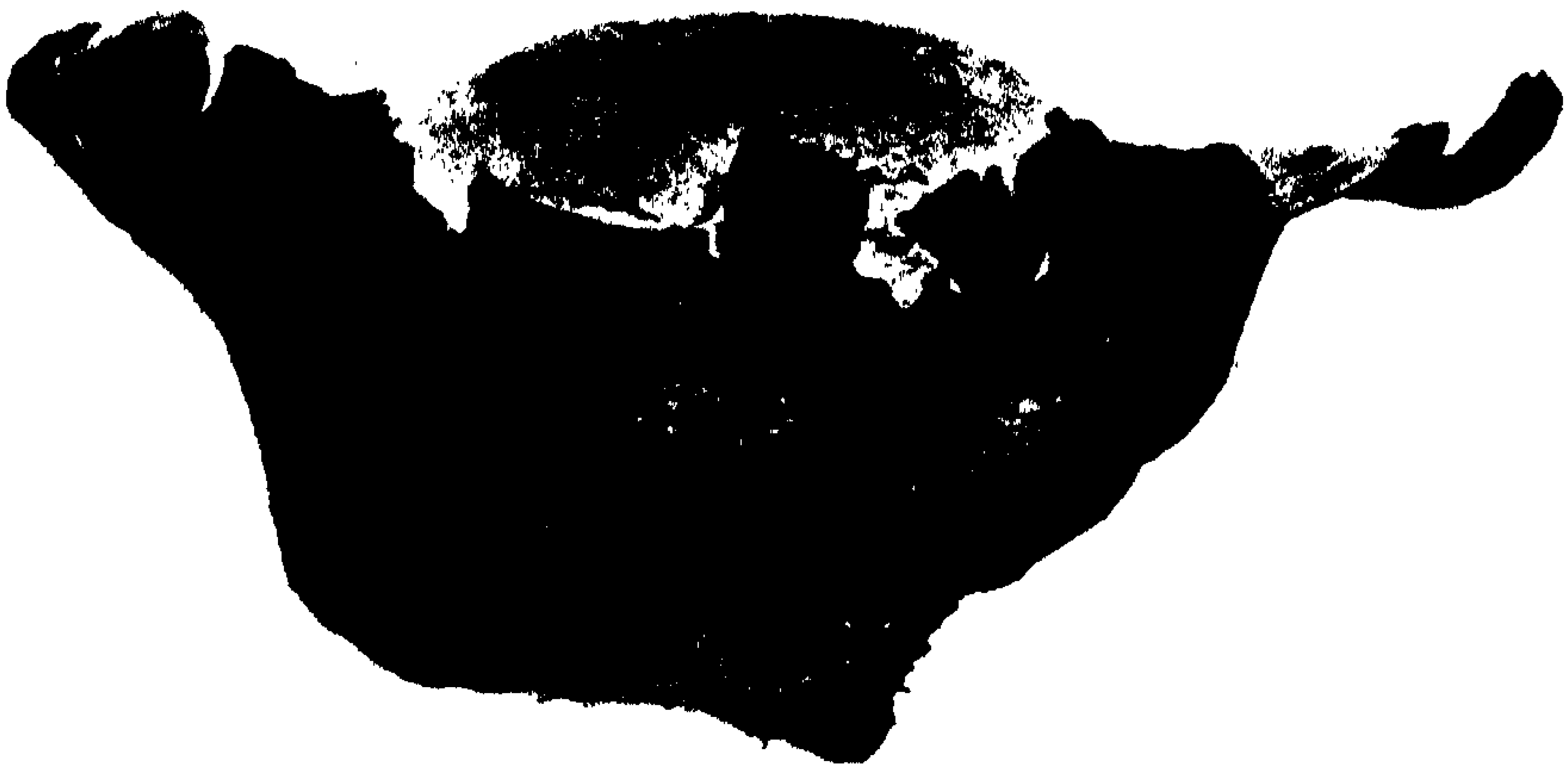
9. *Bassia quinquecuspis* Roly Poly.



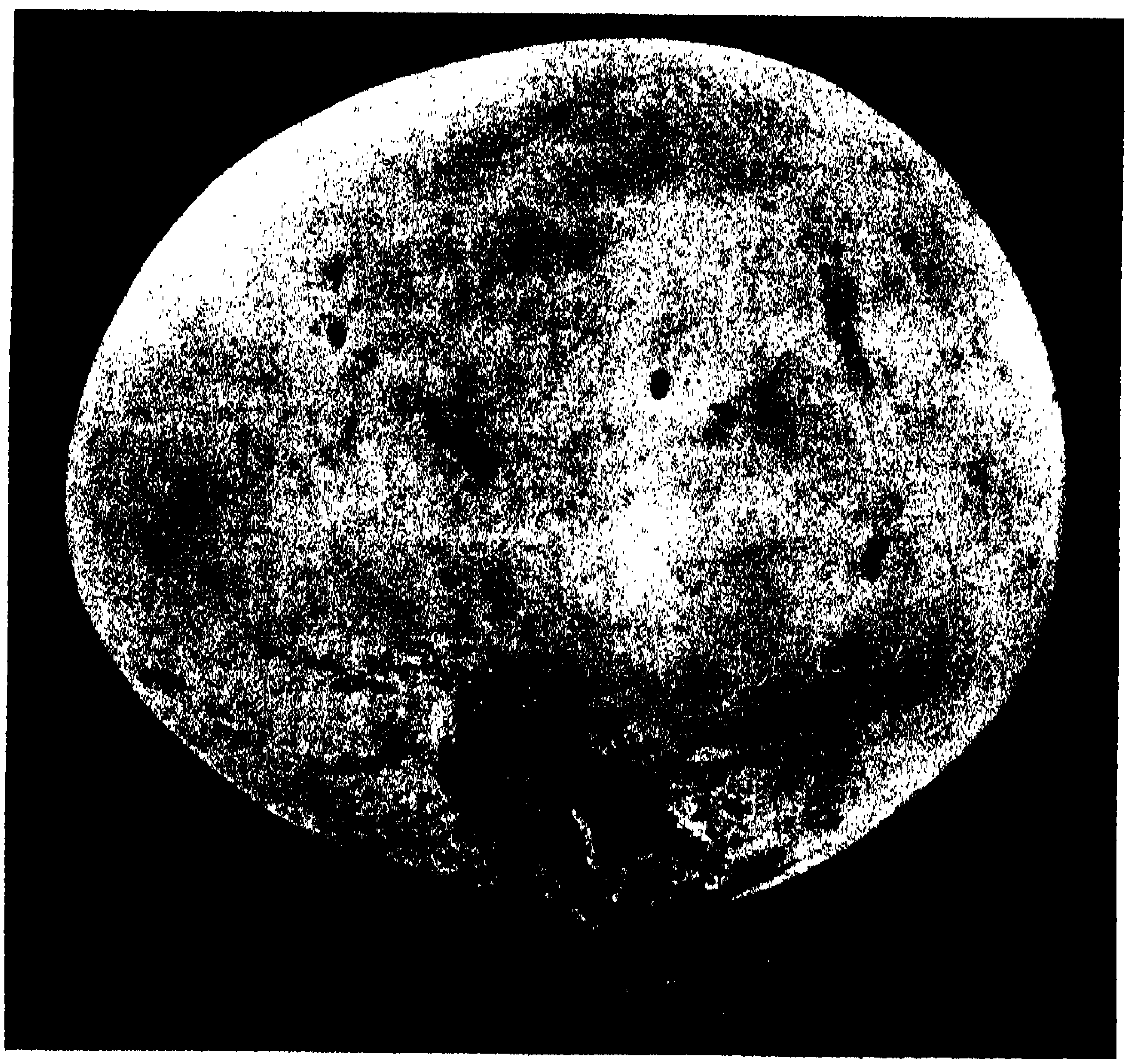
10. *Flindersia maculosa.* Young plant on left; pollarded tree on right.

11. *Petalostigma quadriloculare.*

Eucalyptus Bucknelli, n. sp.

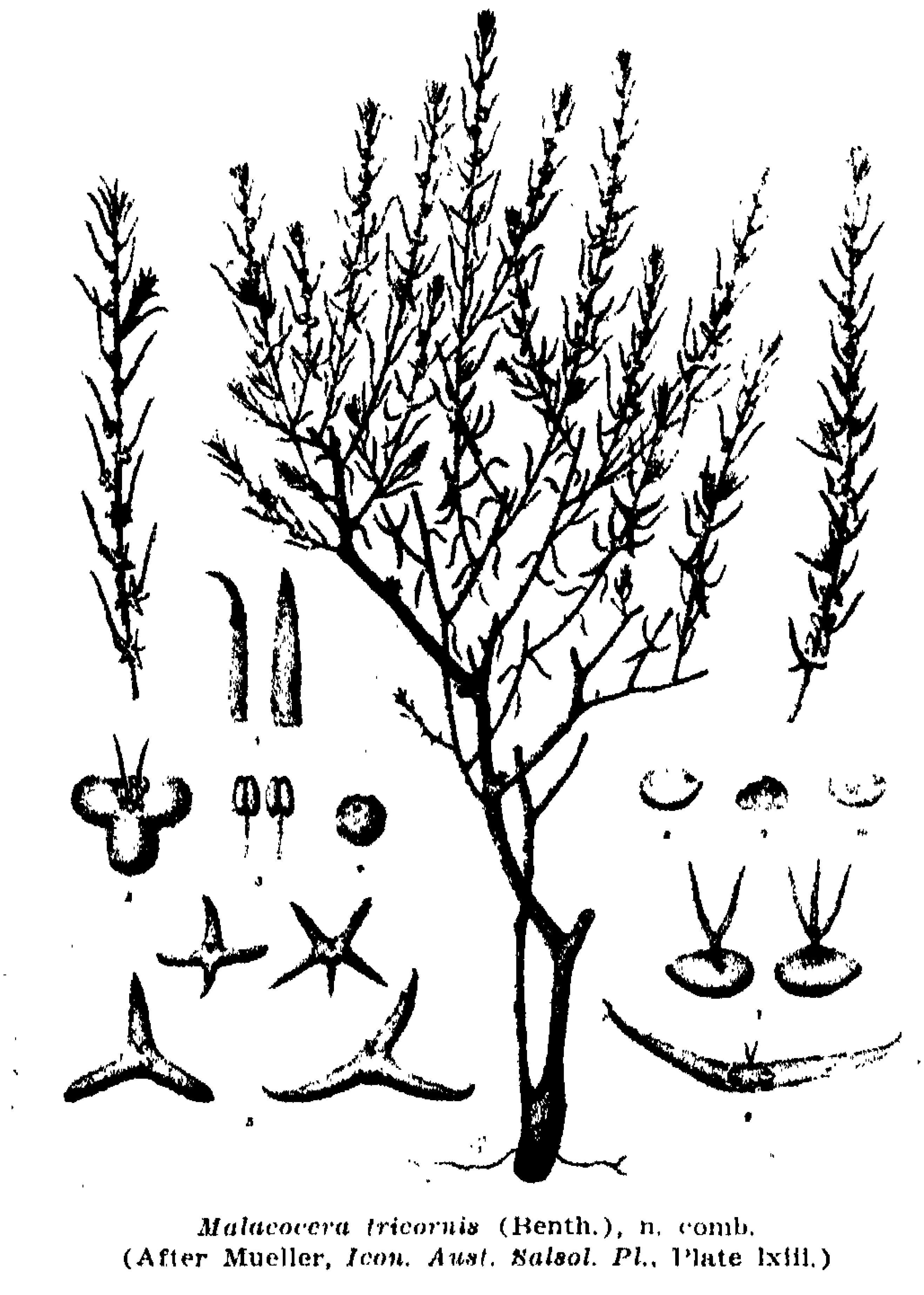


1. *Calvatia lilacina.*

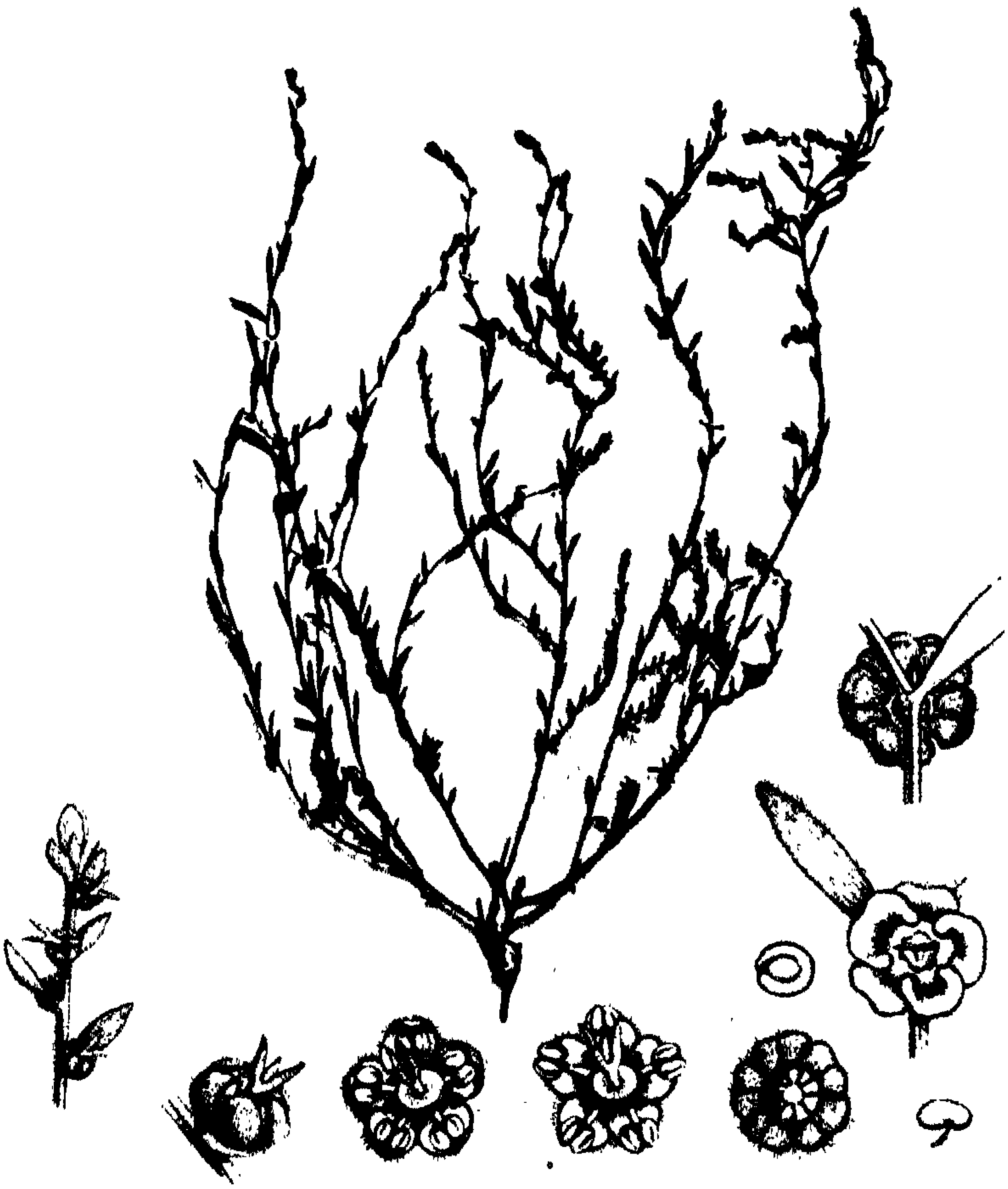


2. *Calvatia gigantea.*

3. *Calvatia caelata.* 4, 5. *C. candida.*



Malacocera tricornis (Benth.), n. comb.
(After Mueller, *Icon. Aust. Salsol. Pl.*, Plate lxiii.)

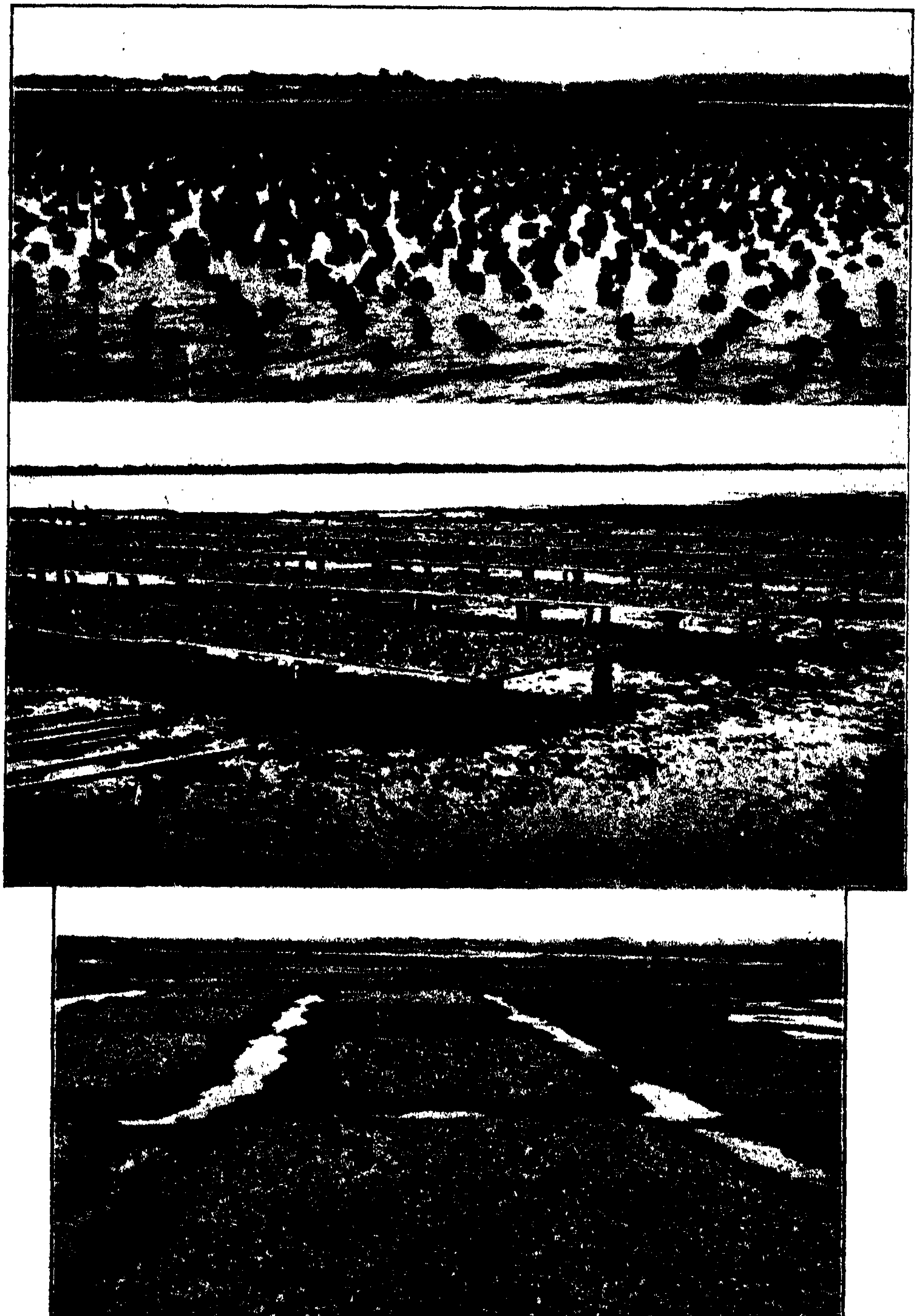


M Flockton del

Kochia crassiloba, n. sp.

Kochia pentagona, n. sp.


GEOLOGICAL MAP
OF THE
MT. MIRANNIE AND MT. DYRRING
DISTRICTS
SCALE
CHAINS
MILES
LARGE AREAS OCCUPIED BY ROCKS OF THE MAIN CLASTIC ZONE AND ASSOCIATED TOSCANITE AND DELLENITE LAVAS (PATERSON TYPE)
To MT. ROYAL
MT. DYRRING
To GLENNIE'S CK.
To SINGLETON
To GRESFORD
THE PASS
MT. MIRANNIE
MIRANNIE FAULT
BENVENUE FAULT
WESTBROOK FAULT
BRIDGEMAN FAULT
ELDERSLIE FAULT
BENVENUE
SPOTTISWOODE
MANRESA
ONE TREE HILL
KUTTUNG SERIES
KUTTUNG
SERIES
NORTHERN PART OF "CRANKY CORNER" BASIN OF PERMIAN ROCKS
LOCALITY SKETCH MAP
LEGEND
CAINOZOIC
Recent Alluvium and Wash
PERMIAN
Coal Measures and Marine Sediments
CARBONIFEROUS
KUTTUNG SERIES
Tuffs, SStones, Fluvioglacial Beds & Varve Rock
Toscanites and Dellenites - Paterson type
Main Clastic Zone with Rhacopteris Flora
Glassy & Lithoidal Hb Bt Andesites - Martins Ck type
Tuffs & Tuffaceous Conglomerates & Sandstones
Felsites of varying composition
Dacites, generally lithoidal, sometimes vitrophyric
Patches of primary Tuff
Pyroxene Andesite
Direction of jointing in the rocks
Fixed points of determined height
Proved Faults
Probable Faults
Motor Roads
Tracks and stock routes
Parish Boundaries
NOTES.
Certain units of volcanic rock, not provided for in the legend, have names indicated on the map.
Many of the smaller outcrops of lavas are either dacitic or felsitic in character.
In most of the larger creeks good outcrops of the Kuttung Series are to be seen, but it has been impossible to record these on the map, as alluvium is generally found on the banks of the streams.
The various Parishes are indicated by large initials, thus:
B stands for Broughton. Da stands for Darlington
D „ „ Dyrring G „ „ Goorangoola
Ma „ „ Marwood M „ „ Mirannie
S „ „ Shenstone Se „ „ Sedgefield
St „ „ Stanhope T „ „ Tangorin
All Parishes are in the County of Durham.



1

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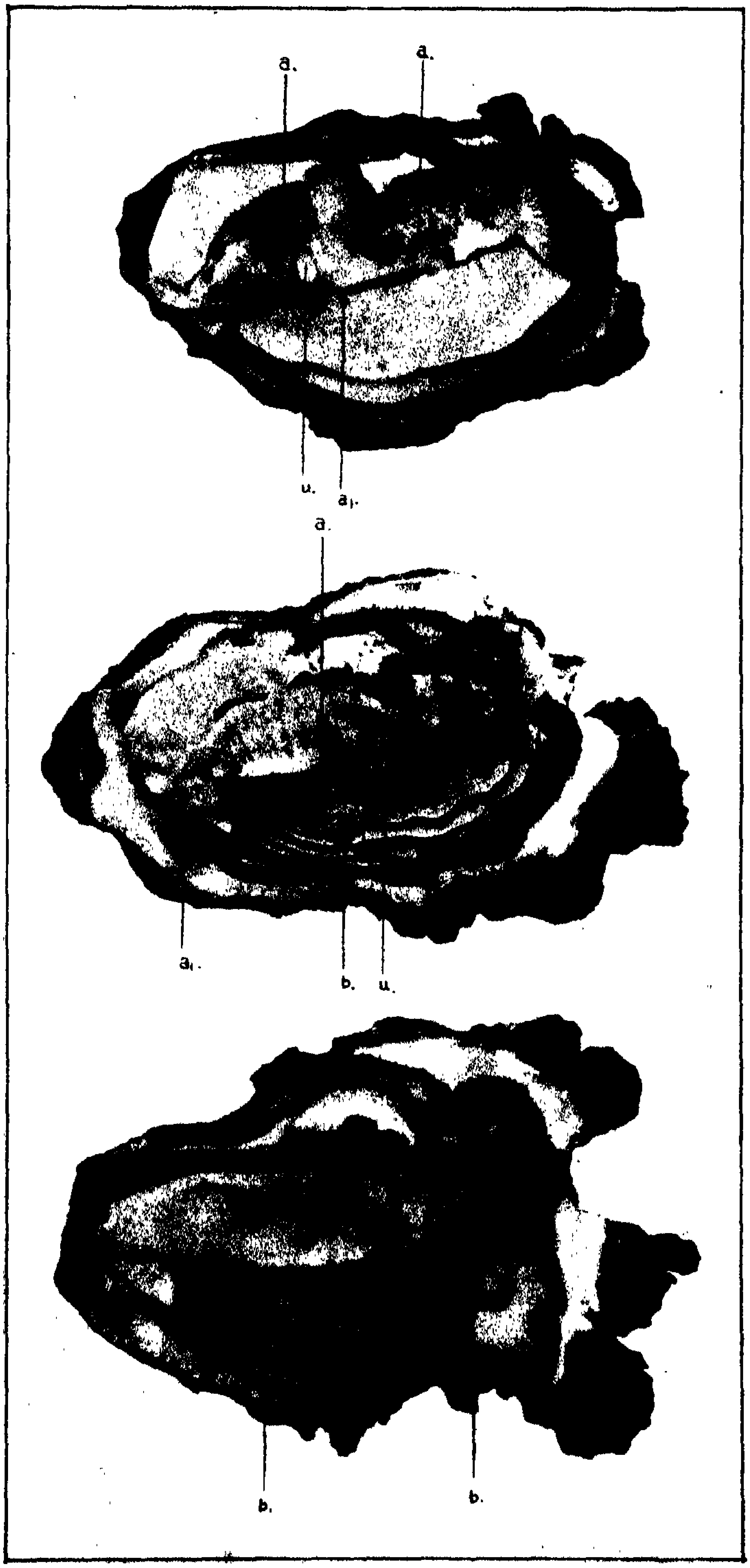
3

Oyster Cultivation: (1) On sandstone slabs, (2) on trays, (3) on shell beds.



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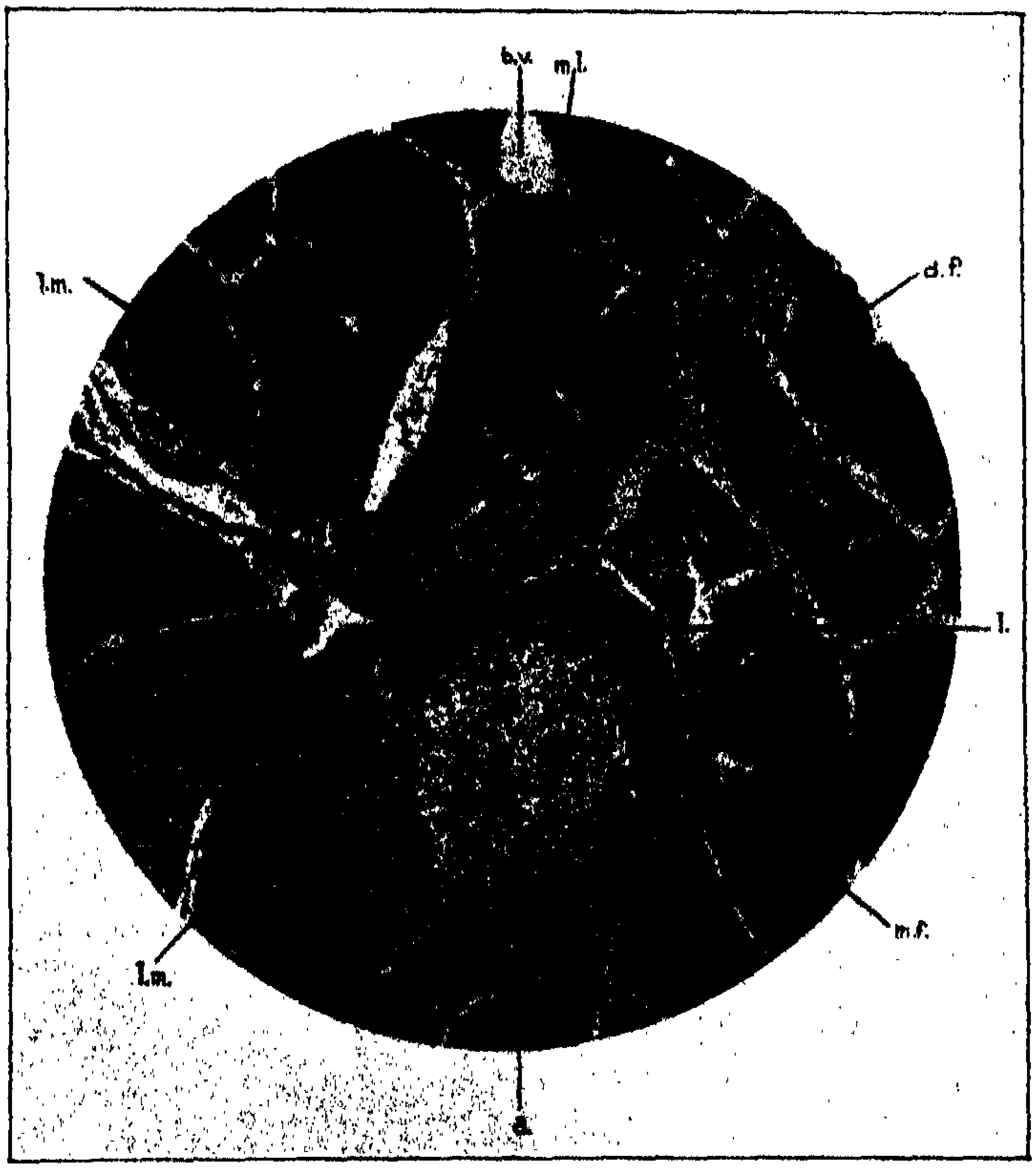
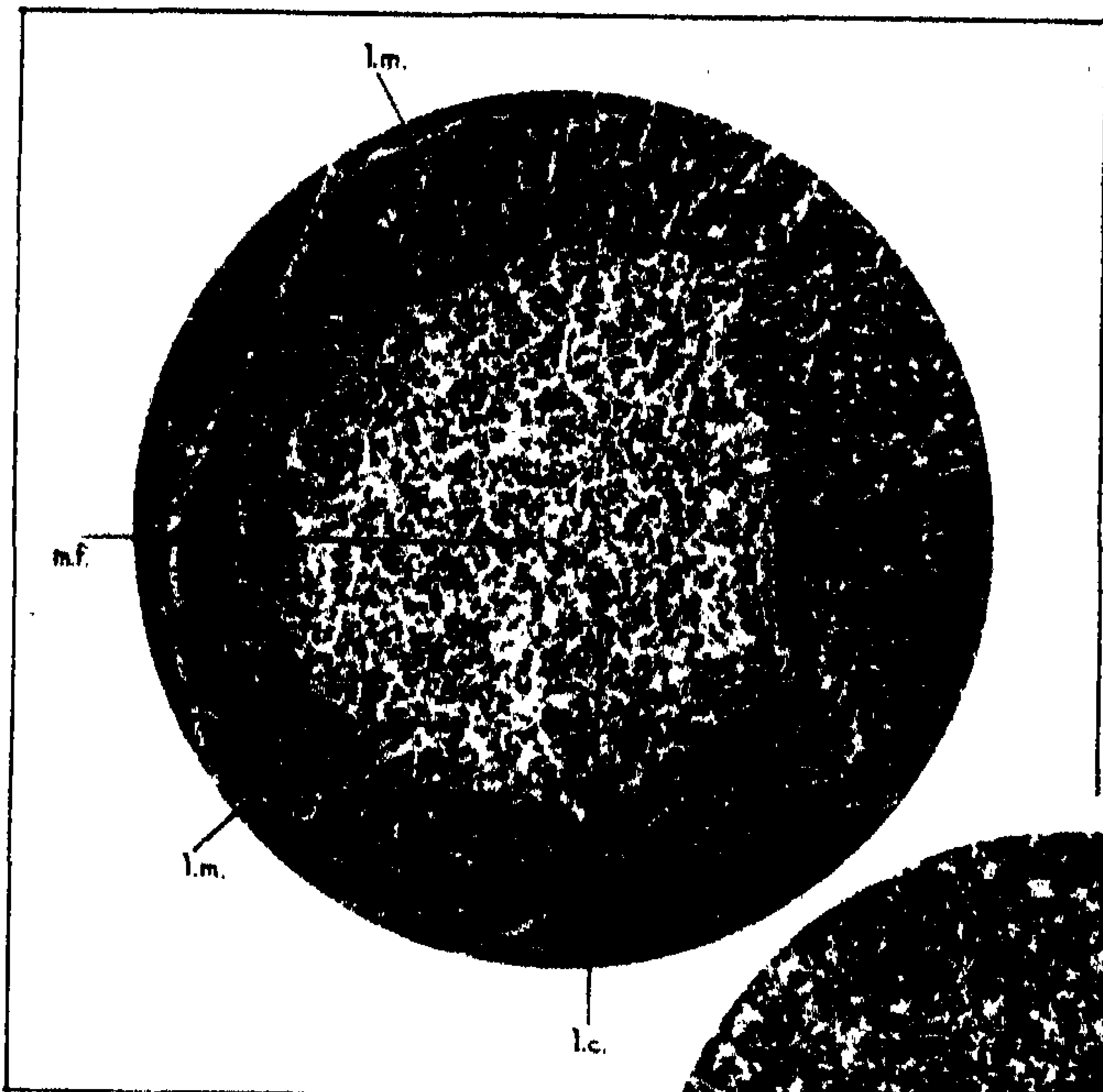
6

Oysters showing abscesses and ulceration.

7. Transverse section of normal tissue of the adductor muscle of oyster.



8. Transverse section of portion of adductor muscle of oyster showing abscess and inflammatory area.



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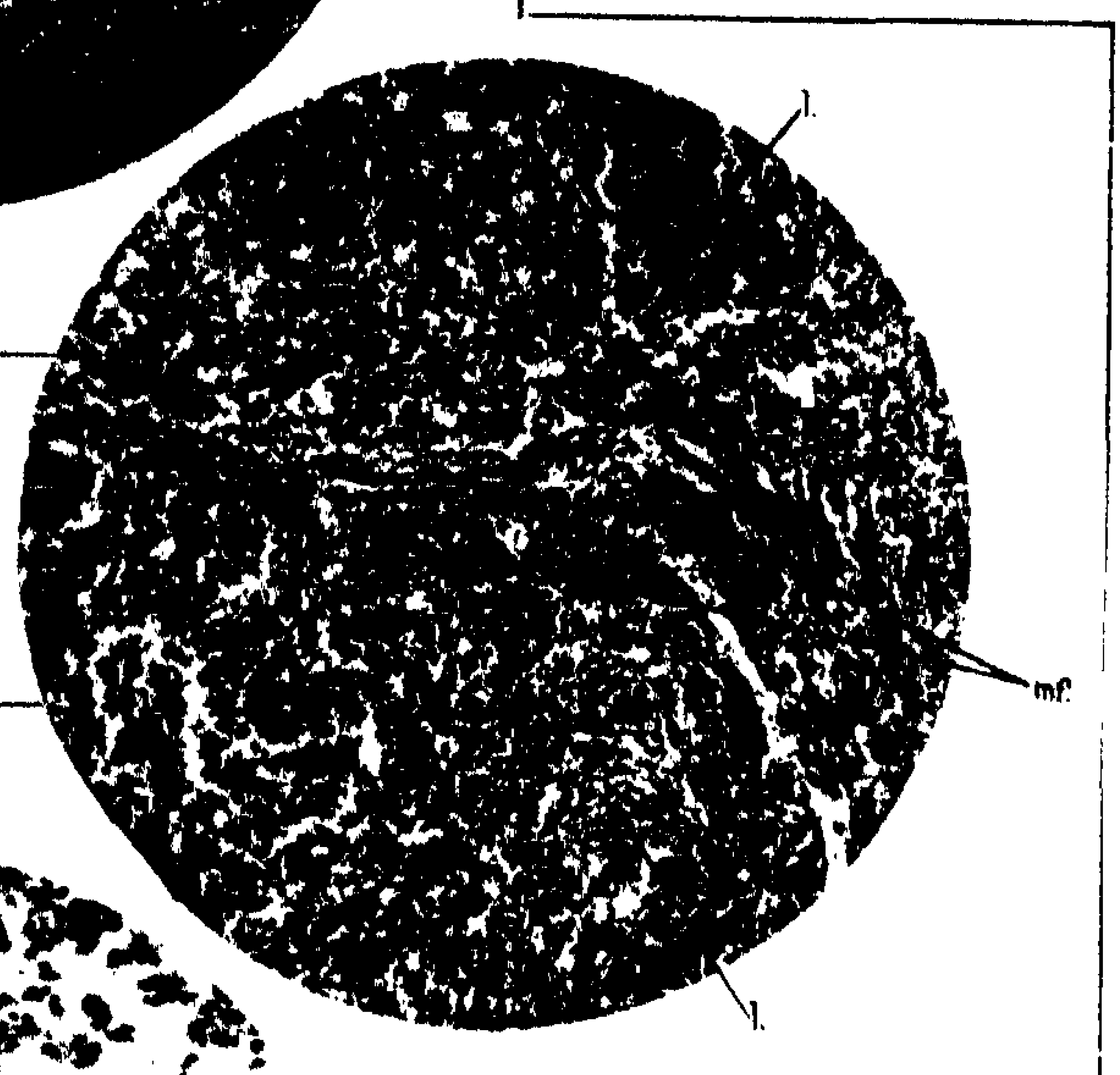

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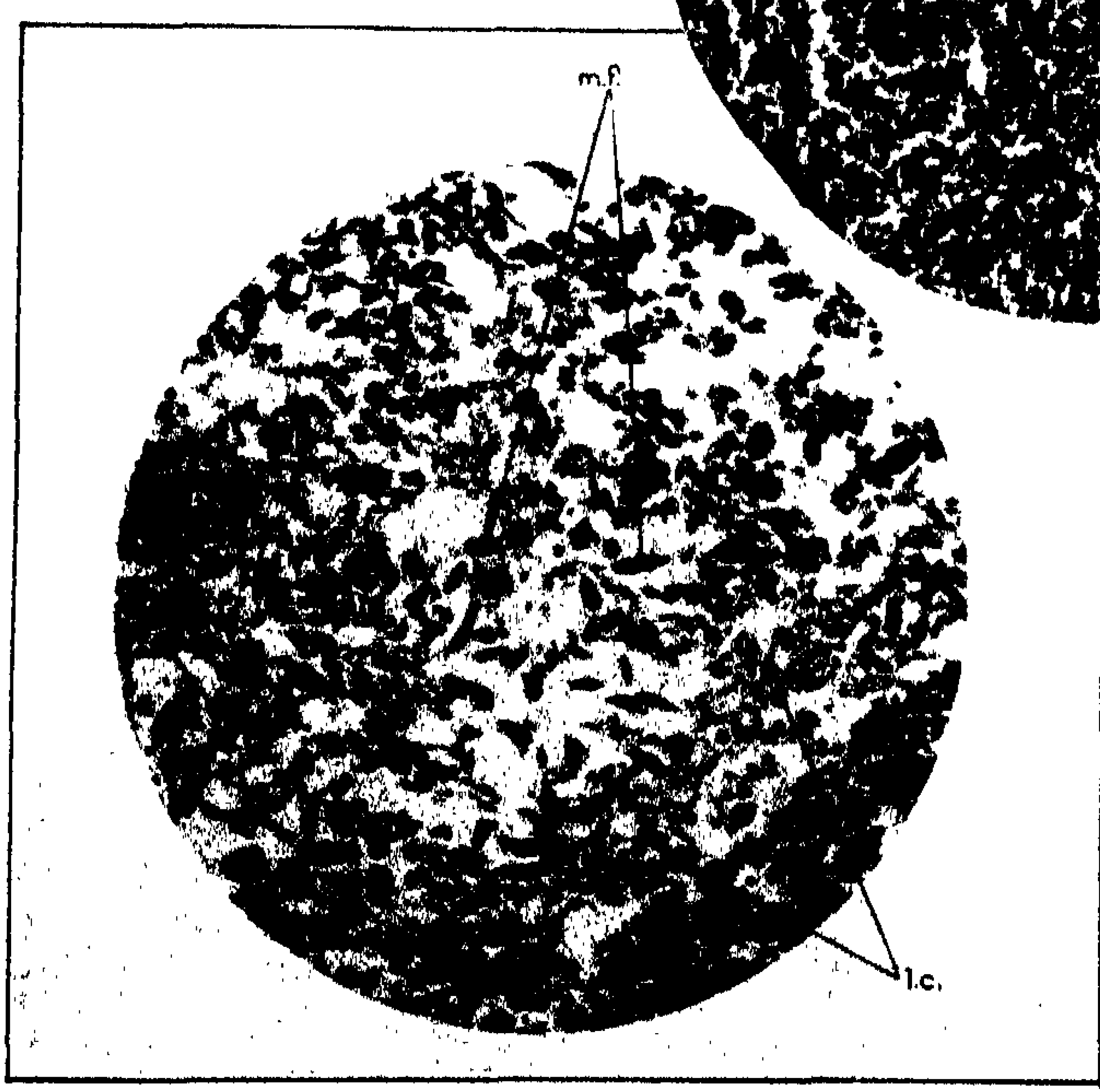
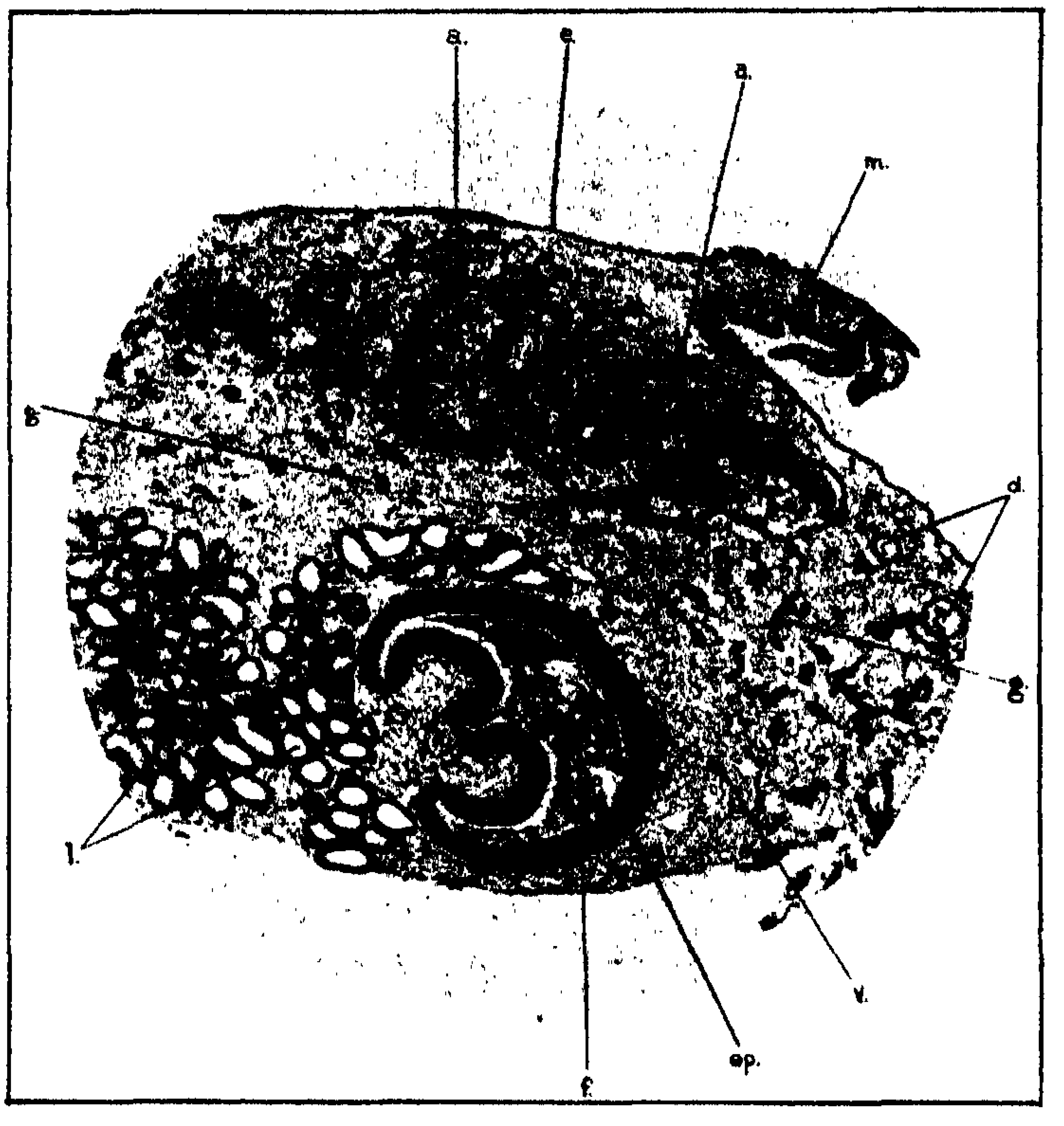
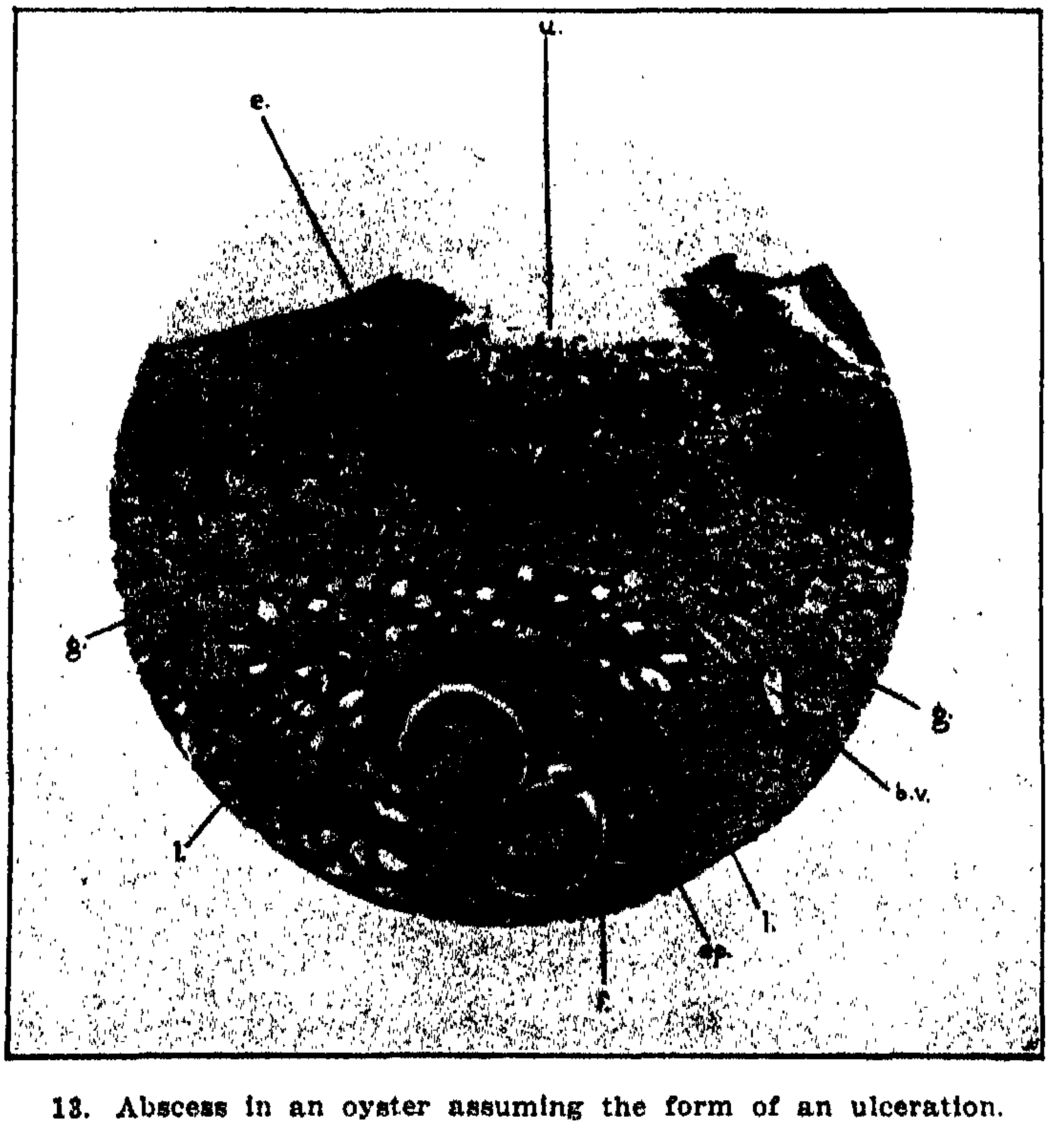


11

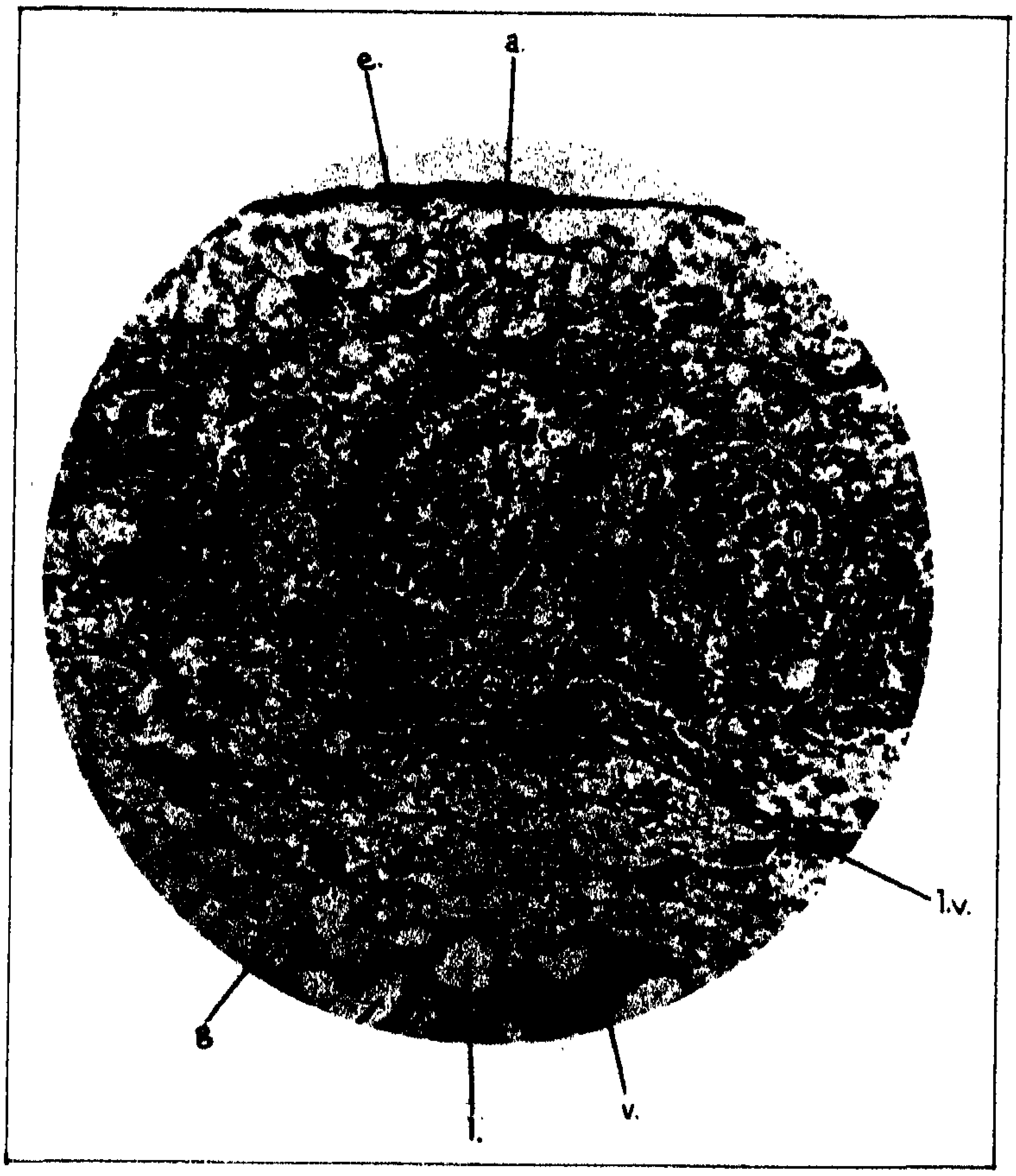
9. The central area of an abscess in the adductor muscle of an oyster.
10. Degenerating muscle tissue in an oyster.
11. Necrosed muscle fibres amongst clusters of blood cells.



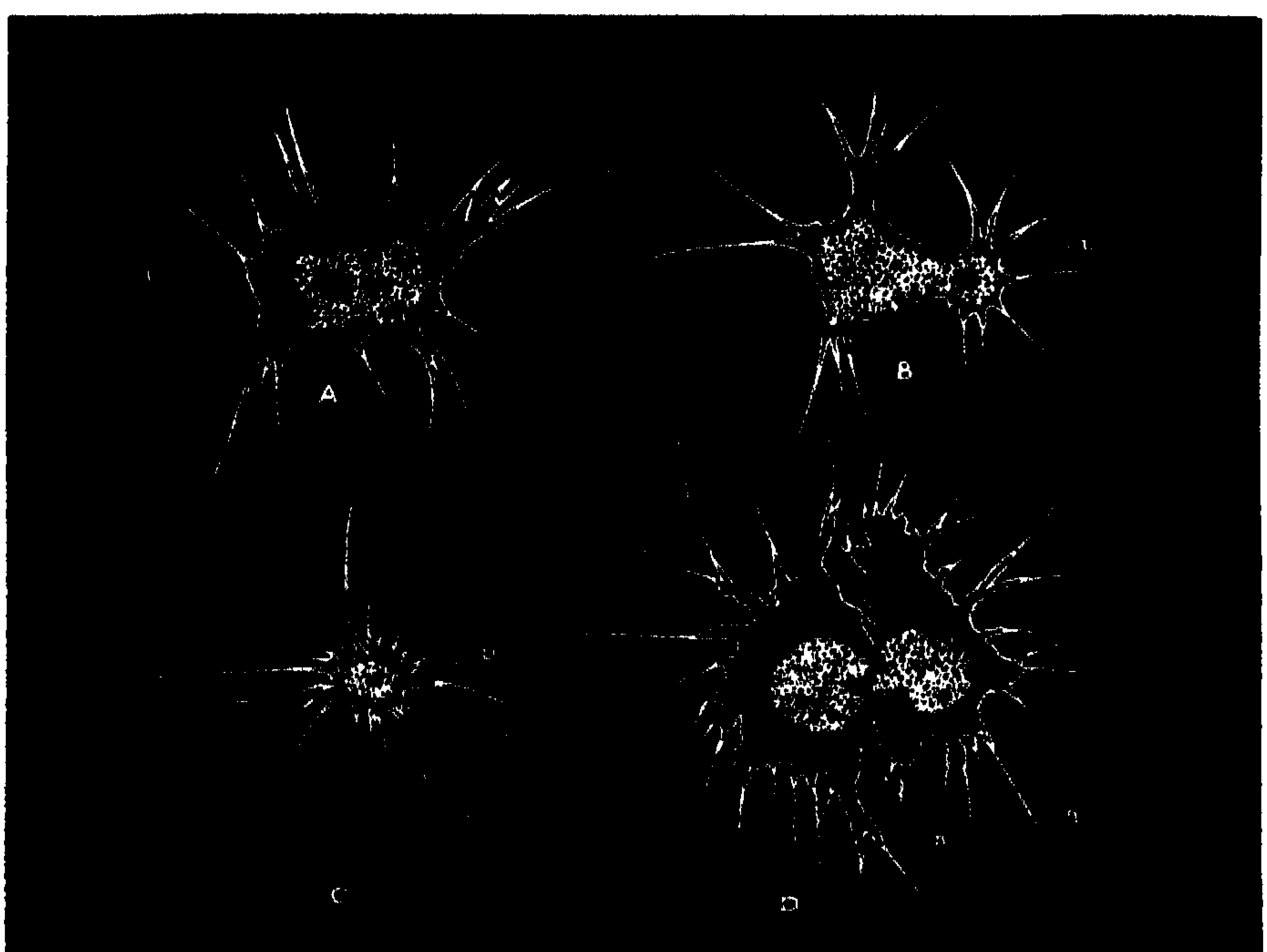
12. Abscesses in the gonad of oyster.



13. Abscess in an oyster assuming the form of an ulceration.



14. Abscesses shown in Plate xxxiii, fig. 12, more highly magnified.



15. Live blood cells of the oyster. D is seen in a state of division.

1

2

3

1. The famous Presbyterian Chapel at Ebenezer.
2. View of the Douglass Farmland at Leet's Vale showing its typical "trough valley" formation.
3. View of Webb's Creek at its junction with the Hawkesbury River.

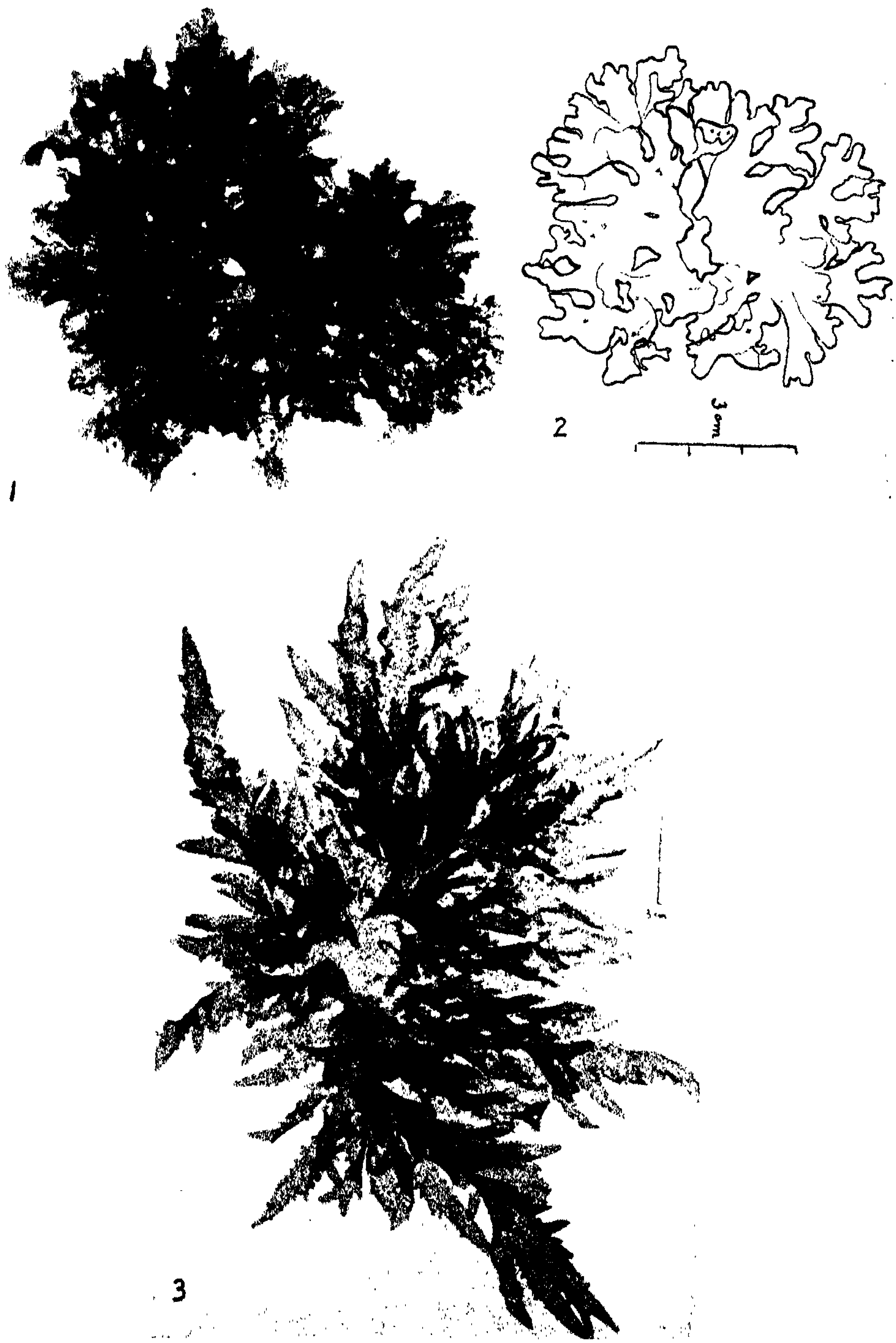
1

2

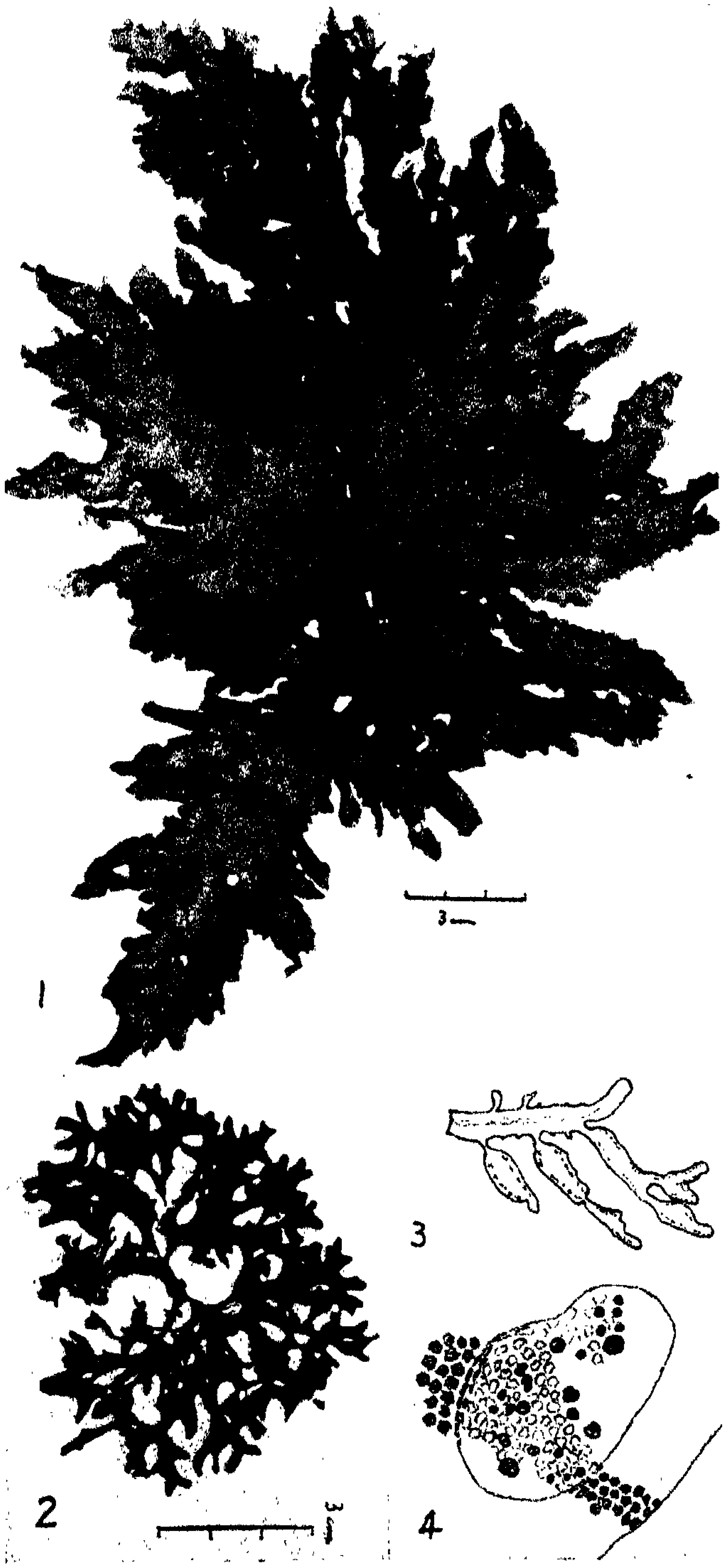
3

4

1. The Township of Wiseman's Ferry, looking south.
2. The incised meander of the Hawkesbury River at Leet's Vale.
3. An isolated sandstone knoll surrounded by farmland, in the vicinity of St. Alban's on the Macdonald River.
4. View of the Macdonald River to the north of St. Alban's.



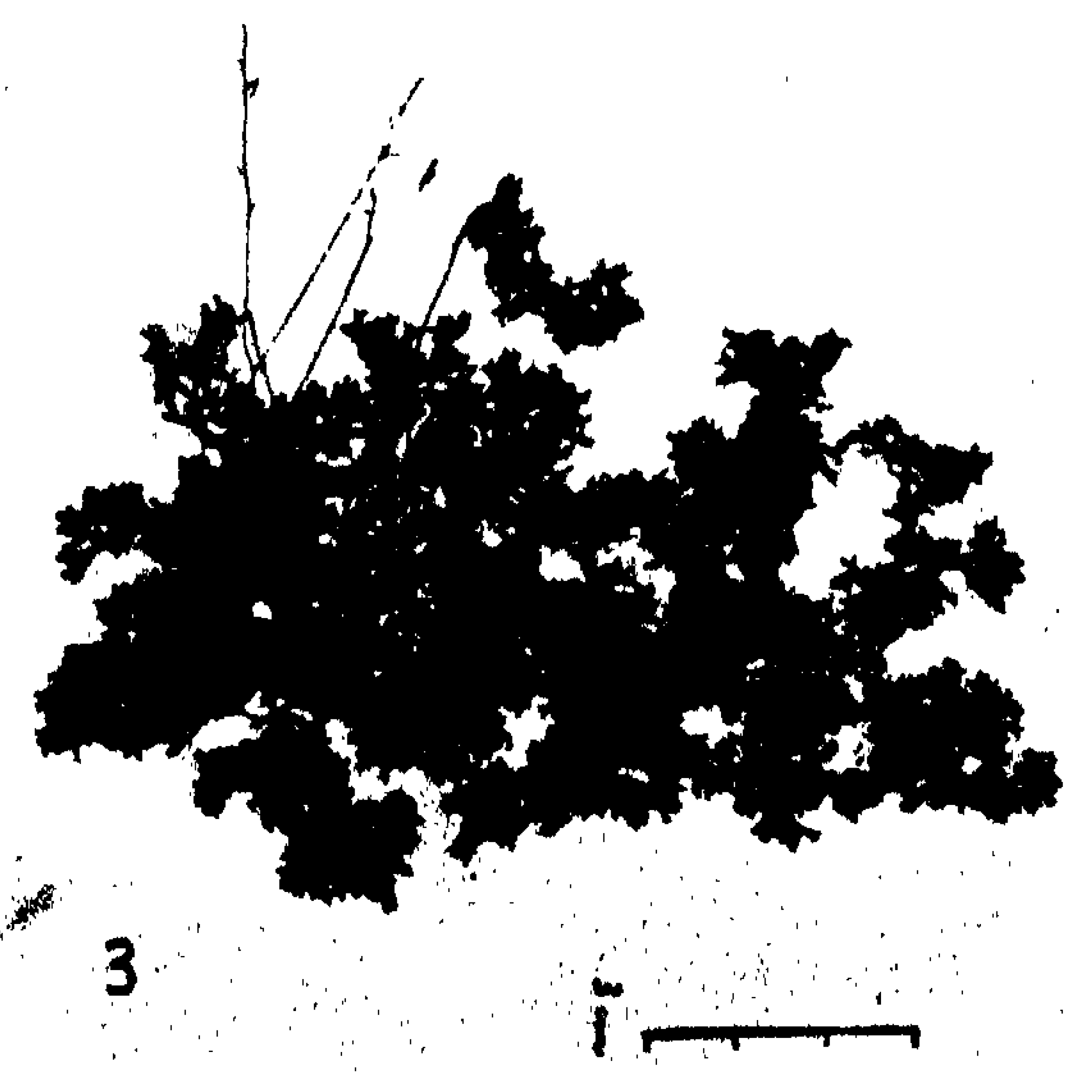
1, 2. *Nitophyllum pulchellum.* 3. *N. crispum.*



1. *Nitophyllum crispum.* 2. *N. cartilagineum.* 3, 4. *N. proliferum.*

1

2



3

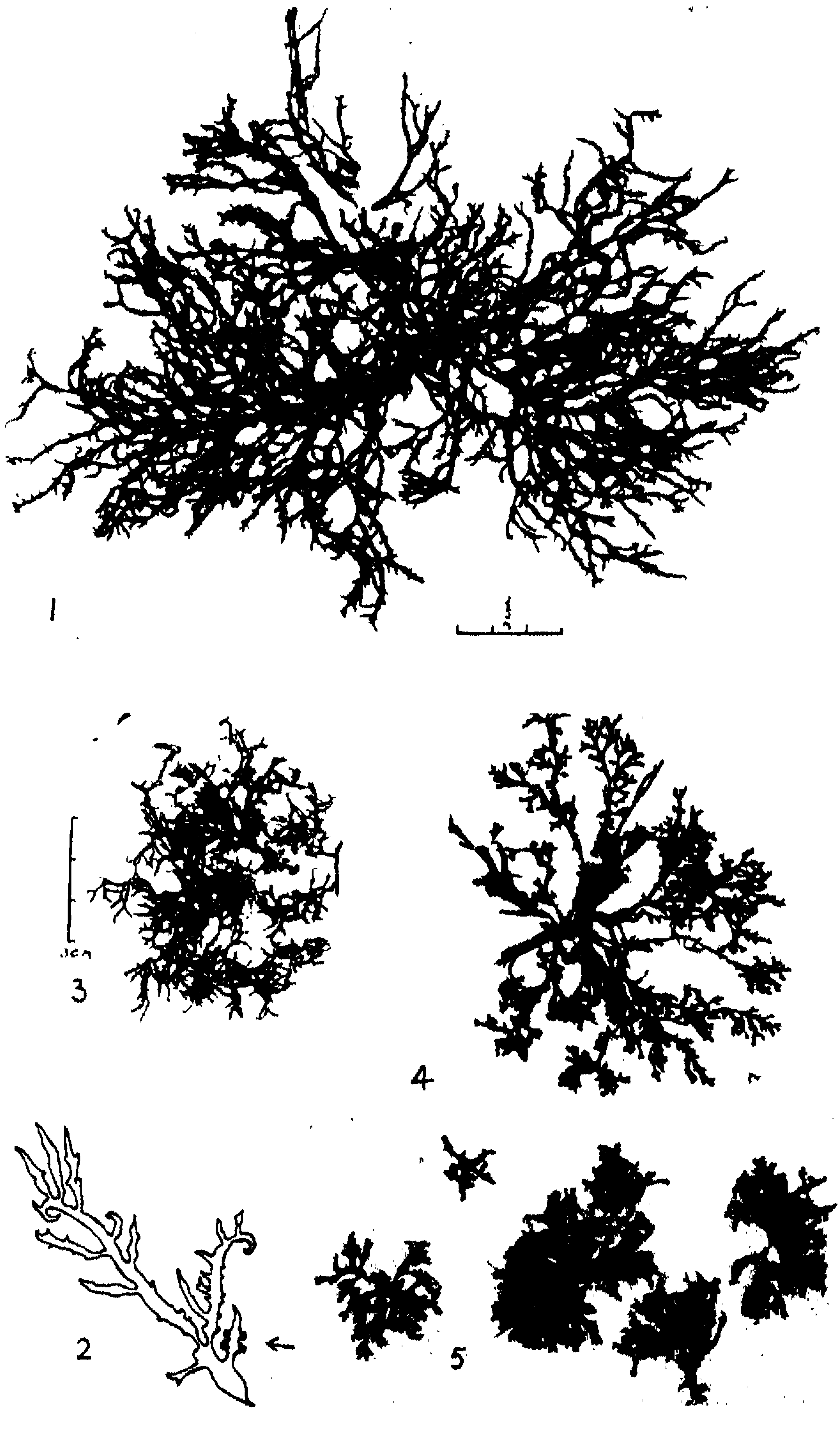
1. *Nitophyllum proliferum*. 2. *N. monanthos*. 3. *N. endivaefolium*.

1.

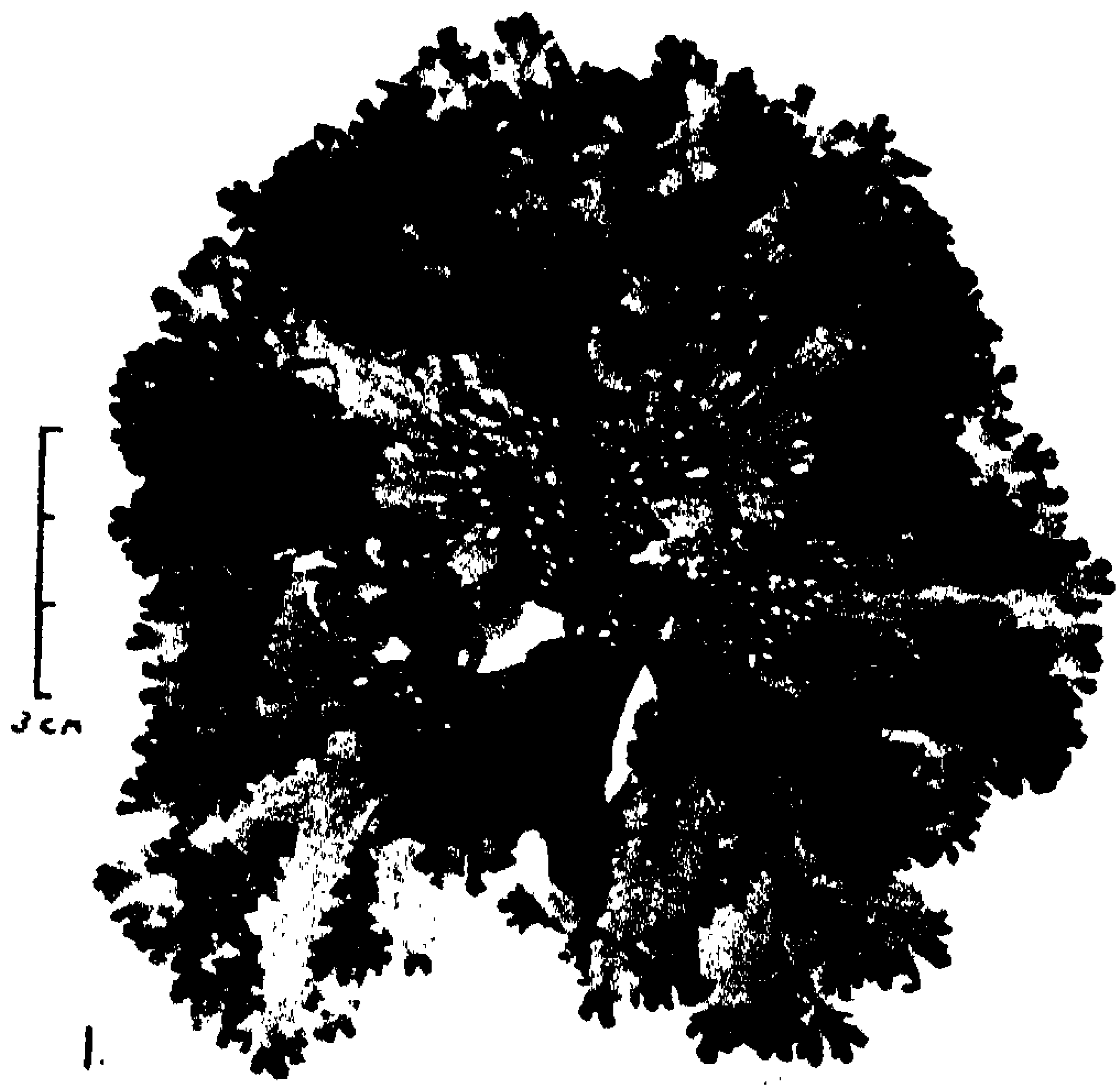
2

1. *Nitophyllum fallax*. 2. *N. gattyanum*.

1-3. *Nitophyllum gattyanum*. 4. *N. hymenema*.



1, 2. *Nitophyllum uncinatum.* 3. *N. ciliolatum.* 4-5. *N. minus.*



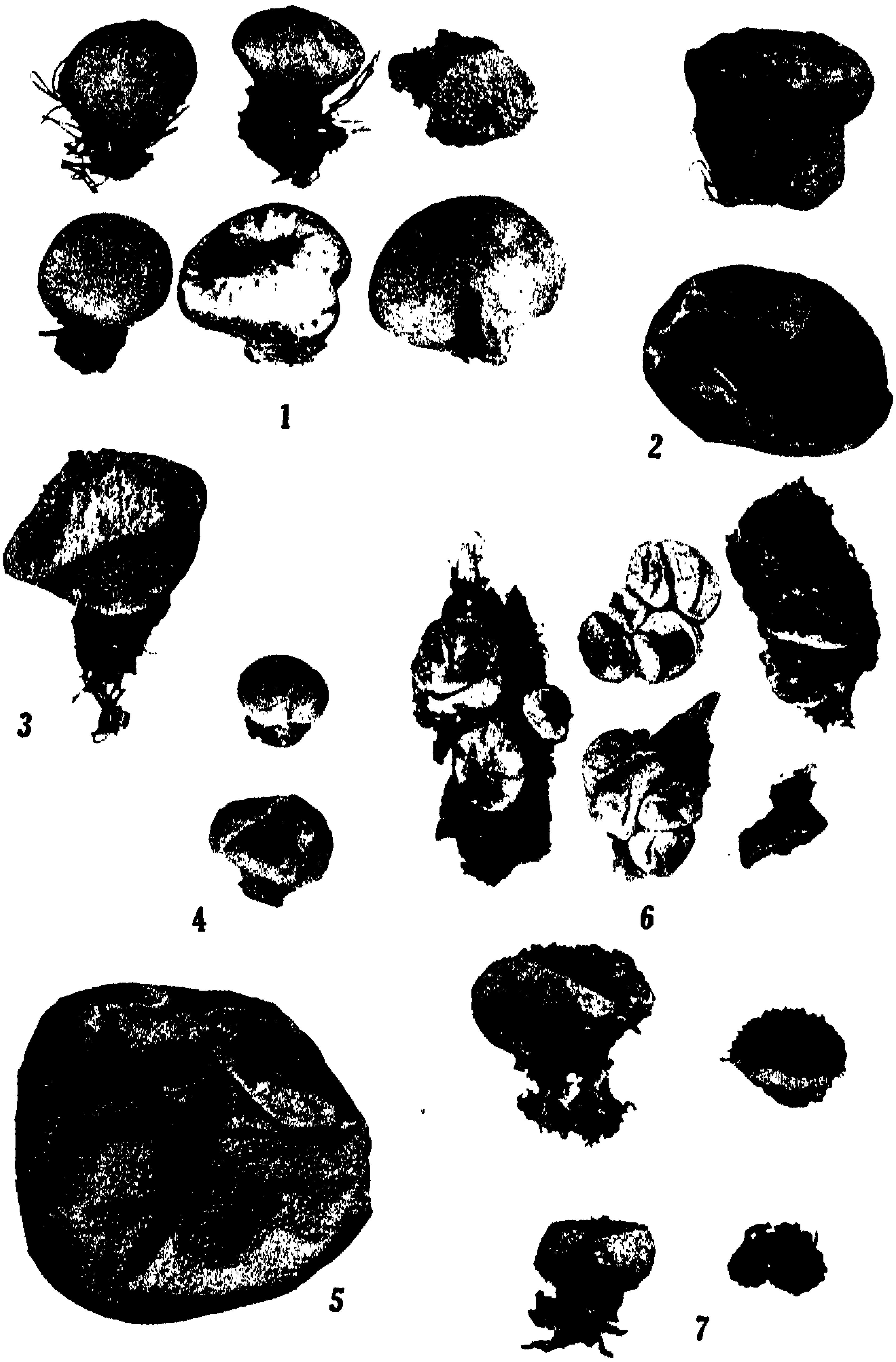
1. *Nitophyllum affine* var. *lobatum*. 2. *N. affine*.

1 2. *Nitophyllum multipartitum.* 3. *N. parvifolium?*

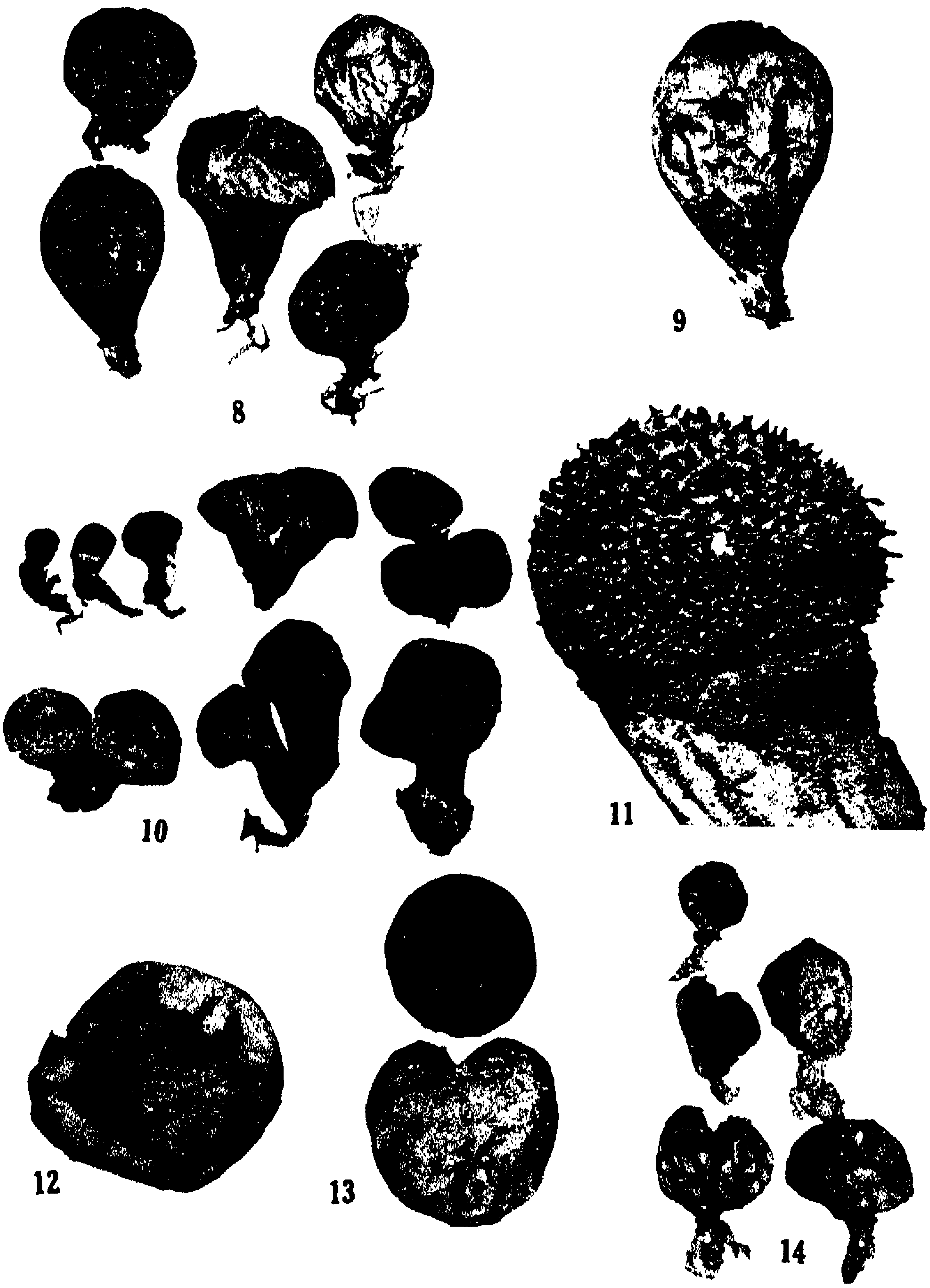
1

2

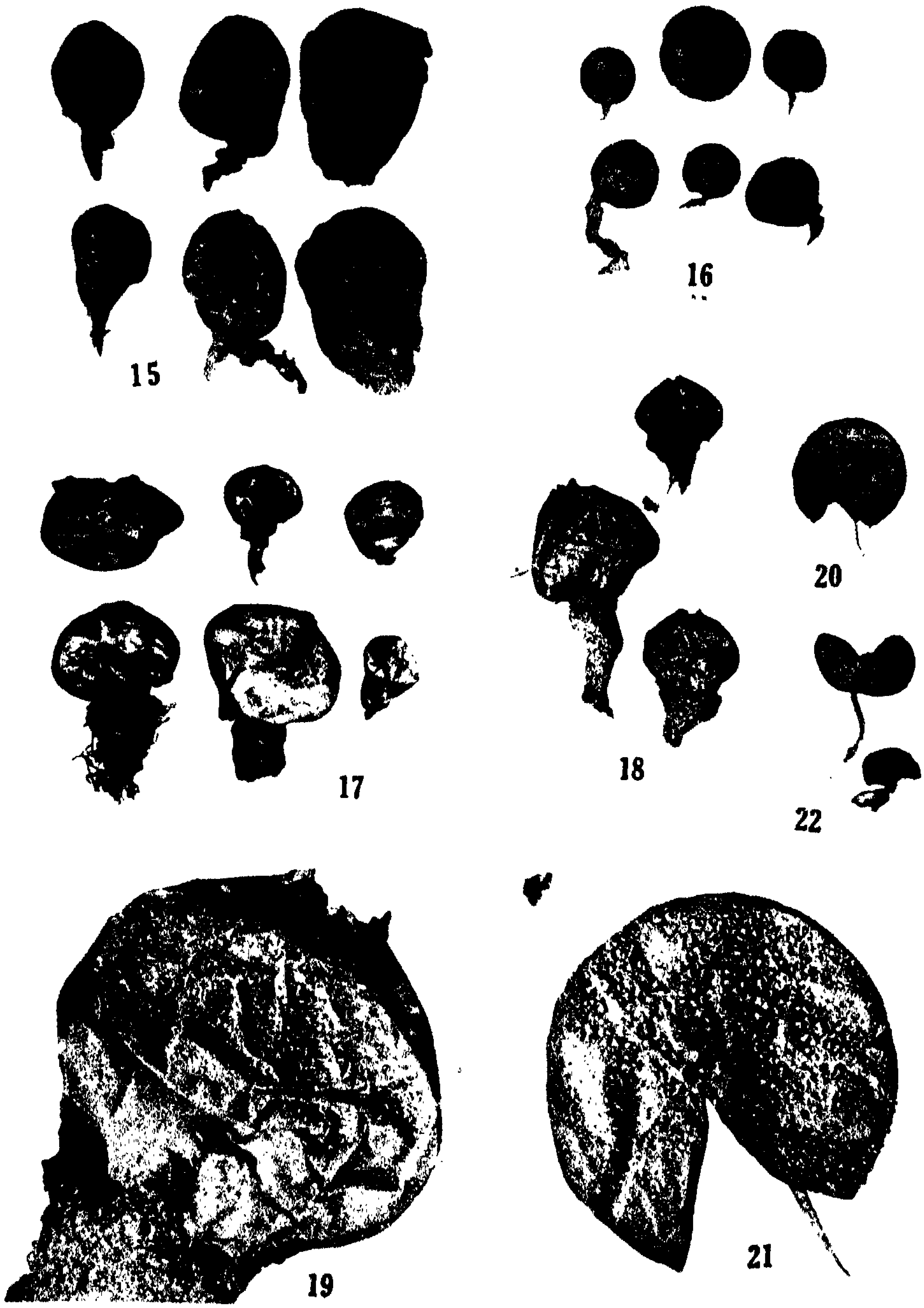
1. *Nitophyllum polyanthum.* 2. *N. curdieanum.*



Australasian species of *Lycoperdon*.



Australasian species of *Lycoperdon*.



Australasian species of *Lycoperdon*.

Date of issue.	Date of issue.	Date of issue.
1-3-35		
7 JUN 1953		
15-3-58		
6-8-64		

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